US Army Corps of Engineers
Waterways Experiment Station

Technical Report GL-97-6
June 1997

RFI Interim Measure, Geophysical Investigation, SWMU 02/11, Dye Burial Grounds, Naval Surface Warfare Center, Crane Division, Crane, Indiana

by José L. Llopis, Michael K. Sharp, William L. Murphy

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Prepared for Department of the Navy
Southern Division Naval Facilities Engineering Command

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U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
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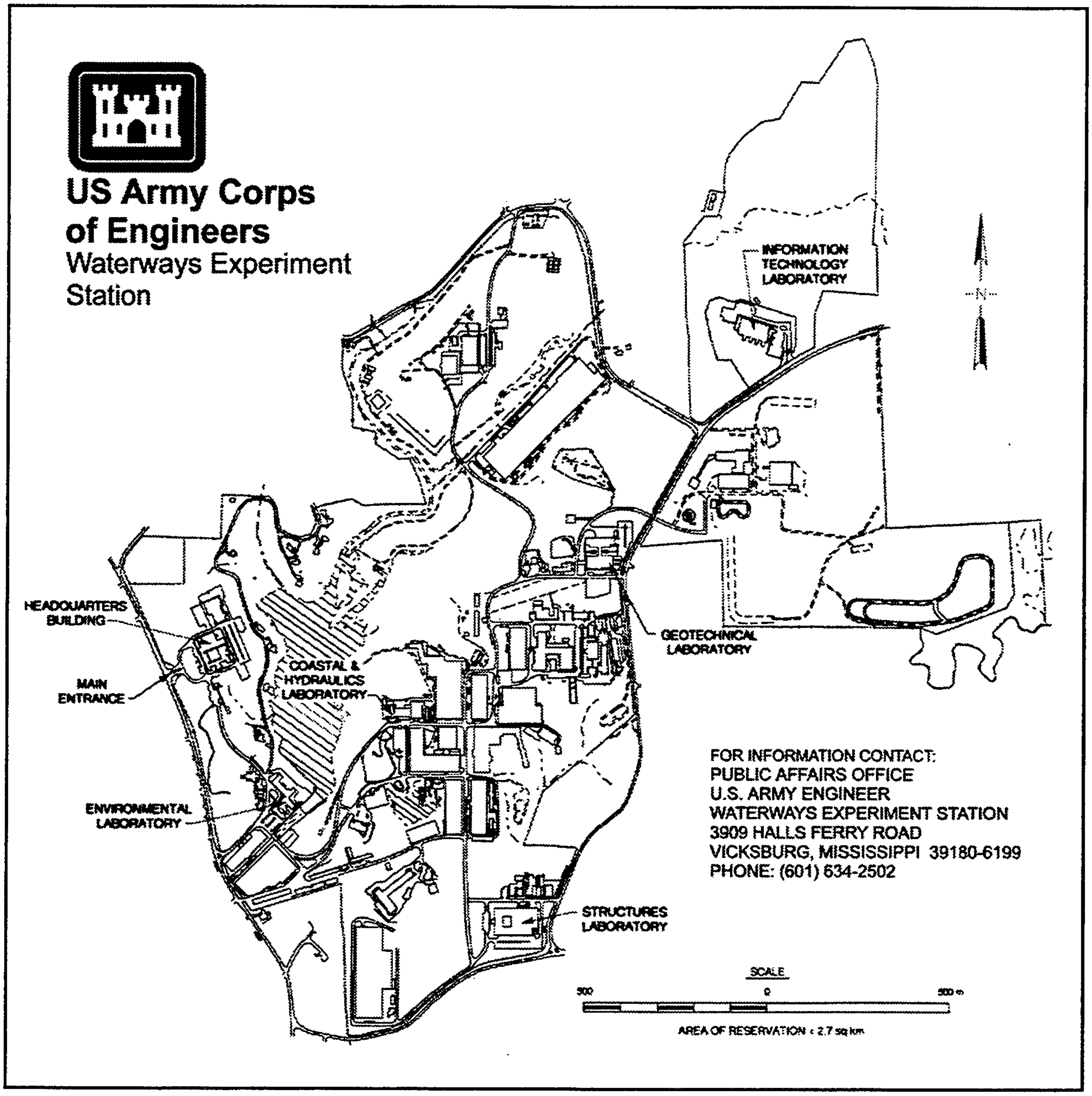
Final report

Prepared for Department of the Navy
Southern Division Naval Facilities Engineering Command
North Charleston, NC 29419-9010



Waterways Experiment Station Cataloging-in-Publication Data

Llopis, Jose L.

RFI interim measure, geophysical investigation, SWMU 02/11, dye burial grounds, Naval Surface Warfare Center, Crane Division, Crane, Indiana / by Jose L. Llopis, Michael K. Sharp, William L. Murphy ; prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command.

63 p. : ill. ; 28 cm. -- (Technical report ; GL-97-6)

Includes bibliographic references.

1. Geophysics -- Indiana -- Crane. 2. Waste disposal in ground -- Indiana -- Crane. 3. Ground penetrating radar. 4. Hazardous waste sites -- Indiana -- Crane. I. Sharp, Michael K. II. Murhpy, William L. (William Lee), 1944- III. United States. Army. Corps of Engineers. IV. U.S. Army Engineer Waterways Experiment Station. V. Geotechnical Laboratory (U.S. Army Engineer Waterways Experiment Station) VI. United States. Navy Dept. VII. United States. Naval Facilities Engineering Command. Southern Division. VIII. Title. IX. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; GL-97-6.
TA7 W34 no.GL-97-6

Contents

IN5 170 023 498

April 30, 1997

Preface

A geophysical investigation was conducted at the Dye Burial Grounds, Naval Surface Warfare Center, Crane Division (NSWCCD), Crane, IN, by personnel of the Geotechnical Laboratory (GL), U.S. Army Engineer Waterways Experiment Station (WES), between 23 and 26 January 1991. The work was performed for the U.S. Naval Facilities Engineering Command, Northern Division, Philadelphia, PA, under Navcomp Project Order N62472-91MPO0010. The NSWCCD Project Engineer was Mr. Thomas Brent.

This report was prepared by Messrs. José L. Llopis and Michael K. Sharp, Engineering Geophysics Branch (EGB), Earthquake Engineering and Geosciences Division (EEGD), and Mr. William L. Murphy, Engineering Geology Branch, EEGD. The work was performed under the direct supervision of Mr. Joseph R. Curro, Jr., Chief, EGB, and under the general supervision of Drs. A. G. Franklin, Chief, EEGD, and William F. Marcuson III, Director, GL. The field investigation was performed by Messrs. Llopis, Sharp, and Murphy. Data analysis and interpretation were performed by Mr. Llopis.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
Fahrenheit degrees	5/9	Celsius degrees or kelvins[1]
feet	0.3048	meters
gammas	1	nanoTeslas
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers
millimhos per foot	3.28	milliSiemens per meter
pounds	0.4535924	kilograms

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C=(5/9) (F-32). To obtain kelvin (K) readings, use: K=(5/9) (F-32)+273.15.

1 Introduction

Background

Under the former Navy Assessment and Control of Installation Pollutants, an Initial Assessment Study (IAS) was conducted at the Naval Surface Warfare Center, Crane Division (NSWCCD), Crane, IN. The 1983 IAS identified and assessed sites of potential threat to health or to the environment by contamination from past hazardous materials operations (Eakes et al. 1983). The Dye Burial Grounds (DBG), located in Section 21, T5N, R3W was one of fourteen sites identified as warranting further assessment under the Navy's Installation Restoration Program (IRP). The Resource, Conservation and Recovery Act (RCRA) Federal Hazardous Waste Storage Permit issued to NSWCCD by the U.S. Environmental Protection Agency in 1989 required Corrective Actions (RCRA Section 3004) be performed at listed Solid Waste Management Units (SWMUs). A RCRA Facility Investigation (RFI) Interim Measure, Source Location Geophysical Survey was required for the DBG. This investigation was conducted to comply with the Permit's Corrective Action requirements.

The IAS (1983) study team reported that an estimated 50 thousand pounds of various dyes and dye-contaminated materials were deposited into open trenches at the DBG from 1952 until 1964. Three main trenches, estimated to be 10 ft wide, 50 ft long and 6 ft deep, reportedly included magnesium, boxes and rags contaminated with dyes, and about 60 drums of dyes. Precise location of the burial trenches was not available from records. Personnel of the U.S. Army Waterways Experiment Station (WES) installed a system of ground water monitoring wells in the uppermost aquifer at the DBG in 1981 (Dunbar 1982) and subsequent ground water sampling and analysis was conducted.

Objectives

Personnel from WES conducted a geophysical investigation at the DBG, SWMU 02/11 in January 1991. The objective of the investigation was to detect and delineate anomalies indicative of buried waste, waste containers, and boundaries of burial trenches. Electromagnetic (EM), magnetic, and ground penetrating radar (GPR) surveys were conducted at the site to meet the above objective.

2 Disposal Area Characteristics

Disposal Area Location

The location of NSWCCD is shown in Figure 1. The DBG is located in the eastern part of NSWCCD just east of the Ammunition Burning Ground (Figure 2). The topographic setting at and near the DBG is shown in Figure 3. The numbers in Figure 3 represent monitoring well emplaced for the IRP. It is noted that the location of the burial trenches shown in Figure 3 are only approximate.

Operating Practices

The DBG is an old burial site reportedly used from the 1940's until 1964 for disposal of scrap materials including dyes. The potentially toxic or carcinogenic dyes reportedly overflowed the trenches during heavy rains (Eakes et al. 1983).

General Physical Conditions

The DBG sits atop a northeast trending ridge (Figure 3). Ground water monitoring wells emplaced around the trench area in 1981 and 1988 indicate that the uppermost ground water (phreatic) zone is 12 to 20 ft below the ground surface, or approximately 6 to 14 ft below the base of the trenches as reported in the 1983 IAS. A geologic cross section of the DBG showing the suspected location of the trenches is shown in Figure 4. The top of the ridge is relatively flat and can pond precipitation for a period of time. The burial trenches potentially can receive infiltrating water from snow or rainfall and may contain water in the wet season or during periods of high precipitation. The approximate trench area is devoid of trees and is at least partially topped by a gravel roadway. Monitoring well logs indicate that the soil in the area surrounding the trenches is generally a silty clay or silty sand from 5 to 10 ft deep and underlain by sandstone (Murphy 1991). Therefore, the bottoms of the trenches are expected to be either soil or weathered rock. None of the borings penetrated fill material.

The geophysical field investigation was conducted during 23 and 26 January 1991. The temperature during the performance of the investigation ranged between approximately 20° and 40° F. The depth of the frost zone was estimated to be less that 2 in. and is not considered to have affected the test results. The water table is deemed to have little effect on the test results since, for the majority of the site, the depth to the water table is greater that 15 ft (Figure 4).

3 Geophysical Test Principles and Field Procedures

Geophysical Test Principles

Electromagnetic surveys

The EM technique is used to measure differences in terrain conductivity. Like electrical resistivity, conductivity is affected by differences in soil porosity, water content, chemical nature of the groundwater and soil, and the physical nature of the soil. For a homogeneous earth, the true conductivity is the reciprocal of the true resistivity. Some advantages of using the EM over the electrical resistivity technique are (1) less sensitivity to localized resistivity inhomogeneities, (2) no direct contact with the ground required, thus no current injection problems, (3) smaller crew size required, and (4) rapid measurements (McNeil 1980).

The EM equipment used in this investigation are frequency-domain electromagnetic instruments consisting of a coplanar transmitter and receiver coil set a fixed distance apart. The transmitter coil is energized with an alternating current at an audio frequency (KHz range) to produce a time varying magnetic field that in turn induces small eddy currents into the ground. These currents generate secondary magnetic fields that are sensed, together with the primary field, by the receiver coil.

There are two components of the induced magnetic field measured by the EM equipment. The first is the quadrature phase component, which gives the ground conductivity measurement. The units of conductivity are millimhos per meter (mmho/m) or, in the SI system milliSiemens per meter (mS/m). The second component is the inphase component, which is used primarily for calibration purposes. However, the inphase component is much more sensitive to large metallic objects and therefore very useful when looking for buried metal containers (Geonics 1984). When measuring the inphase component, the true zero level is not known since the reference level is arbitrarily set by the operator. Therefore, measurements collected in this mode are relative to an arbitrary reference level and have units of parts per thousand (ppt).

Geonics model EM31 and EM38 ground conductivity meters were used to survey the DBG. The EM31 has an intercoil spacing of 12 ft and an effective depth of exploration of about 20 ft (Geonics 1984). The EM31 meter reading is a weighted average of the earth's conductivity as a function of depth. A thorough investigation to a depth of 12 ft is usually possible, but below that depth the effect of conductive anomalies becomes more difficult to distinguish. The EM31, when carried at a usual height of approximately 3 ft, is most sensitive to features at a depth of about 1 ft. Half the instrument's readings result from features shallower than about 9 ft, and the remaining half from below that depth (Bevan 1983). Figure 5 more clearly illustrates the effect of depth on instrument sensitivity with the dashed lines depicting the sensitivity of the instrument to objects between it and the ground surface. The instrument can be operated in both a horizontal and vertical dipole orientation (Figure 6) with correspondingly different effective depths of exploration. The instrument is normally operated with the dipoles vertically oriented (coils oriented horizontally and coplanar) which gives the maximum depth of penetration. The instrument can be operated in a continuous or a discrete mode. Figure 7 shows the EM31 in use.

The EM38 operates under the same principles as described for the EM31. The EM38 has an intercoil spacing of 3 ft allowing for a maximum depth of investigation of approximately 6 ft. Although the EM38 has a shallower depth of investigation than the EM31, it has a correspondingly greater horizontal resolution capability. The EM38 is shown in Figure 8.

The EM31 and EM38 data can be presented in profile plots or as isoconductivity contours, if data are obtained in a grid form. A more thorough discussion on EM theory and field procedures is given by Butler (1986), Telford et al. (1973) and Nabighian (1988).

Magnetic surveys

The magnetic method of surveying is based on the ability to measure local disturbances of the earth's magnetic field. Magnetic anomalies are caused by two different types of magnetism: induced and remanent magnetization. Remanent magnetization is a permanent magnetic moment per unit volume whereas induced magnetization is temporary magnetization that disappears if the material is removed from a magnetic field. Generally, the induced magnetization is parallel with and proportional to the inducing field (Barrows and Rocchio 1990). The remanent magnetism of a material depends on the thermal and magnetic history of the body and is independent of the field in which it is measured (Breiner 1973).

A Scintrex model MP-3/4 proton precession magnetometer, as shown in Figure 9, was used to measure the total field intensity of the local magnetic field. The local magnetic field is the vector sum of the field of the locally magnetized materials (local disturbance) and the ambient (undisturbed) magnetic field.

Figure 10 shows the ambient earth's field as 50,000 nT with a local disturbance of 10 nT. Figure 10 shows that the quantity measured with the magnetometer is the resultant total field with a value of 50,006 nT. The magnetometer was also used with dual sensors thereby allowing the vertical gradient of the total magnetic field to be measured. The gradient is taken by measuring the difference in values between two sensors which are a fixed small vertical distance apart. The difference in values between the two sensors divided by their separation distance approximates the vertical gradient measured at the midpoint of the two sensors. Two advantages of using the magnetic gradient are that (1) the regional magnetic gradient is filtered out thus better defining local anomalies and (2) since the two readings are taken a short time apart magnetic storm effects and diurnal magnetic variations are essentially removed (Breiner 1973). The magnetic unit of measurement is the nanotesla (nT) or gamma (γ). One nanotesla is equivalent to one gamma. The magnetometer used in this investigation has an absolute accuracy of approximately ± 1 nT. For reference, the earth's magnetic field varies from approximately 60,000 nT at the poles to 30,000 nT at the equator (the nominal field strength at NSWCCD is 55,100 nT).

A magnetic anomaly represents a local disturbance in the earth's magnetic field that arises from a localized change in magnetization, or magnetization contrast. The observed anomaly expresses the net effect of the induced and remanent magnetization and the earth's ambient magnetic field, and depends on its mass, magnetization, shape and orientation, and state of deterioration. Detection of the anomaly and hence the localized subsurface feature depends on the magnitude and spatial wavelength relative to local magnetic noise and anomalies caused by other magnetic sources.

Ground penetrating radar surveys

Ground penetrating radar (GPR) is a geophysical subsurface exploration method using high frequency EM waves. A block diagram depicting the GPR system is shown in Figure 11. The GPR system consists of a transmitting and a receiving antenna. The transmitting electronics generate a very short duration high voltage EM pulse that is radiated into the ground by the transmitting antenna. The signal is reflected by materials having contrasting electrical properties back to the receiving antenna. The magnitude of the received signal as a function of time after the transmitter has been initiated is measured. The signals are then amplified, processed, and recorded to provide a "continuous" profile of the subsurface.

The transmitted EM waves respond to changes in soil and rock conditions having sufficiently different electrical properties such as those caused by clay content, soil moisture or groundwater, water salinity, cementation, man-made objects, voids, etc. The depth of exploration is determined by the electrical properties of the soil or rock and by the power and frequency of the transmitting

antenna. The primary disadvantage to GPR is its extremely site specific applicability; the presence of high-clay content soils in the shallow subsurface will generally defeat the application of GPR (Olhoeft 1984). High water contents in the shallow subsurface and shallow water tables can also limit the applicability of GPR at some sites. A general rule is that GPR should not be applied to projects in which the mapping objective is greater than 50 ft in depth. For shallow mapping applications at sites with low clay content soils, GPR will generally have the best vertical and horizontal resolution of any geophysical method (Butler and Llopis 1990).

A GSSI System 8 GPR with a 300 MHz antenna as shown in Figure 12 was used for the survey. Assuming a 1 ft per 10 nanosecond two-way travel time, it is estimated that the 300 MHz antenna could penetrate approximately 2 to 3 ft of soil at this site. This depth of penetration should be adequate to determine the top of the burial trenches or pits.

Field Procedures

A grid was established to encompass the area of interest (Figure 13). The grid was nearly rectangular in shape measuring 700 ft by 80 ft. The grid was laid out such that it followed the general trend of the road passing through the site. Densely wooded areas adjacent to the road effectively limited the width of the gridded area to 80 ft. Survey grid positions were referenced to DBG well casings which had previously been surveyed for map location (northing and easting). The grid stations shown in Figure 13 were marked at 20 ft intervals by implanting polyvinyl chloride (PVC) stakes into the ground. PVC stakes were used to prevent interference with the geophysical tests. Magnetic, EM31, and EM38 readings were taken at 10 ft intervals over the entire gridded area. The positions of intermediate stations (between flagged stations) were visually estimated.

The EM31 and EM38 data were collected both in the conductivity (quadrature phase) and inphase modes at each measurement station. The data were collected on a digital data logger as shown in Figure 14 and transferred to a portable field computer at the conclusion of a survey day for storage and future processing.

Total magnetic field and magnetic gradient readings were taken at each survey point. The geophysical data were collected, recorded, and transferred to a laptop computer at the conclusion of the survey for storage and future processing.

The GPR survey was run in a northeast-southwest direction following the long axis of the gridded site. The GPR survey coverage was limited to areas fairly free of trees because of the size of the radar antenna (approximately 3 ft by 3 ft). The area

surveyed with the GPR is shown by the shaded area in Figure 15. Survey lines were spaced 10 ft apart where possible. A total of 2960 linear ft of GPR coverage was collected.

The GPR was hand-towed along each survey line at a slow walking pace (approximately 1 to 2 miles per hour). Grid intersections were established on the radar records by electronically impressing dashed, vertical reference lines on the graphic records as the antenna passed each flagged location. Figure 16 shows a typical GPR field survey in progress.

4 Test Results

EM31 Results

Conductivity

The results of the EM31 conductivity survey are presented in Figures 17 through 19. Each data set is presented in profile, as a contour map (two dimensional view), and as a block diagram (three dimensional view). Figures 17 through 19 indicate that background conductivity values for the site range between 10 and 13 mS/m. Based on the range of the background values two anomalous zones can be distinguished in Figures 18 and 19.

Inphase

The EM31 inphase results are presented in Figures 20 through 22. The results indicate that background values for this area range between approximately 0.3 and 0.8 ppt. The data indicate several anomalously high and low value areas. High and low anomalous areas may be indicative of buried metallic objects. Five high-valued and three low-valued areas were detected and are noted in Figures 21 and 22.

EM38 Results

Conductivity

Figures 23 through 25 present the results of the EM38 conductivity survey. Those areas having conductivity values in excess of 10 mS/m are considered to be anomalous and are accordingly noted in Figures 24 and 25.

Inphase

The results of the EM38 inphase survey are shown in Figures 26 through 28. Values greater than 0.5 and less than -0.8 ppt were regarded as anomalous are indicated in Figures 27 and 28.

Magnetometer Results

Total magnetic field

The total magnetic field survey results are shown in Figures 29 through 31. The data presented in Figures 30 and 31 show a nominal value of 55,100 nT, the regional field, subtracted from the measured field. Five anomalous areas are distinguished in Figures 30 and 31. All of the anomalies shown in the figures correlate with the location of metal-cased observation wells with the exception of the anomaly located at (596350,491180).

Magnetic gradient

The results of the magnetic gradient survey are presented in Figures 32 through 34. The locations of the anomalies interpreted from the survey are indicated in Figures 33 and 34 and the locations are identical to those for the total magnetic field survey.

Ground Penetrating Radar Results

Figure 35 shows examples of GPR profile lines collected at the site. Figure 35a shows no indications of any anomalies whereas Figure 35b shows numerous anomalous features. A total of 11 anomalous regions were identified with the GPR and their locations are shown in Figure 36. Three anomalies are small (less than 10 ft long) with the remaining eight ranging in size from 15 to 100 ft in length.

5 Data Interpretation

In deciding what constitutes significant anomalies for a particular site several factors must be weighed. Anomaly detection is limited by instrument accuracy and local "noise" or variations in the measurements caused by factors not associated with the anomalies of interest such as fences, power lines, metal buildings, etc. (cultural noise). For the anomaly to be significant, the measurement caused by the anomaly must have a response greater than that caused by the interfering cultural noise. Since the anomaly amplitude, spatial extent, and wavelength are the keys to detection, the size and depth of the feature causing the anomaly are important factors in determining detectability and resolution. The intensity of the anomaly is also a function of the degree of contrast in material properties between the anomaly and the surrounding materials.

Based upon the test methods employed, noise conditions at the site and the assumption that the target objects are relatively shallow (less than 10 ft in depth), the areas indicated as anomalous in Chapter 4 Test Results can be considered as significant. In the interpretation of the results, the above criteria were used and refer to anomalies caused by localized contrasts in dielectric constant, electrical conductivity, and magnetic susceptibility. Magnetic lows are not included in the criteria since they are associated with either a magnetic high or an above ground ferrous object. Areas indicated as anomalous from the GPR survey were used to confirm the presence or absence of objects in the study area.

To facilitate visualizing the results of the various surveys conducted at the site, an integrated anomaly map was prepared (Figure 37). This figure shows the anomaly type (magnetic, EM31 conductivity, GPR, etc.), anomaly location and its approximate areal extent. The individual anomalies shown in Figure 37 were gathered into anomaly groups as shown in Figure 38. The groups were located by outlining the areas with anomalous values shown in Figure 37. In some cases the groups contain anomalies identified from more that one test while other groups are based on anomalies from a single survey type. The 13 anomaly groups shown in Figure 38 are described in the table below.

Geophysical Anomaly Interpretation

Anomaly Group No.	EM31		EM38		Magnetics		GPR	Description
	Cond	IP	Cond	IP	TMF	Grad		
1		X						Small area, probably small metallic object.
2							X	Small target, probably shallow soil disturbance.
3		X	X	X			X	Possible burial trenches with small metallic objects.
4		X						Possible small metallic objects.
5							X	Possible disturbed soil and small metallic objects.
6							X	Possible soil disturbance (trench?).
7	X	X	X	X	X	X		Probably a small buried metallic object. TMF and Grad anomalies may be caused by nearby metal casing.
8					X	X		Anomaly probably caused by nearby steel well casing.
9			X	X			X	Disturbed soil with high conductivity (trenches?), possible small metallic objects.
10			X	X	X	X		Probably a small, shallow metallic object.
11							X	Disturbed soil layering (trench?), possible metallic object at approximately (596330,491210)

Geophysical Anomaly Interpretation								
Anomaly Group No.	**EM31**		**EM38**		**Magnetics**			
	Cond	**IP**	**Cond**	**IP**	**TMF**	**Grad**	**GPR**	**Description**
12	X	X	X	X	X	X	X	TMF and Grad anomalies probably caused by nearby steel well casing. EM31 Cond is relatively high in this area. This may be caused by a change in geology (i.e. shale is shallower) or an increase in clay or water content, metallic objects, or ground water conductivity (pollution plume?). The EM31 IP anomalies probably caused by metallic objects. The EM38 Cond anomaly may be caused by an increase in clay or water content. The various GPR anomalies in this area indicate that the disturbed area may be caused by trenching operations.
13					X	X		Anomaly caused by nearby steel well casing.

Note: Cond = Conductivity
IP = inphase
TMF = Total magnetic field
Grad = Magnetic gradient

The geophysical anomalies interpreted above are used to construct a map showing the priority of areas to be further investigated (Figure 39). The priority values shown in Figure 39 range between 1 (highest priority) and 5 (lowest priority). The priority values on the map are based on the number, kind, and size of the anomalies interpreted from the geophysical surveys.

6 Conclusions and Recommendations

A geophysical investigation consisting of EM, magnetic, and GPR surveys was conducted at NSWCCD to delineate zones suspected of being used for the burial of various waste materials. Several of the areas surveyed are interpreted as having anomalous readings and are noted. The interpreted anomalous areas may be caused by soil disturbance caused by trenching activities or materials contained within them. It is recommended that the anomaly priority map be used as a referrence when considering which and in what order anonmalous areas should be further investigated.

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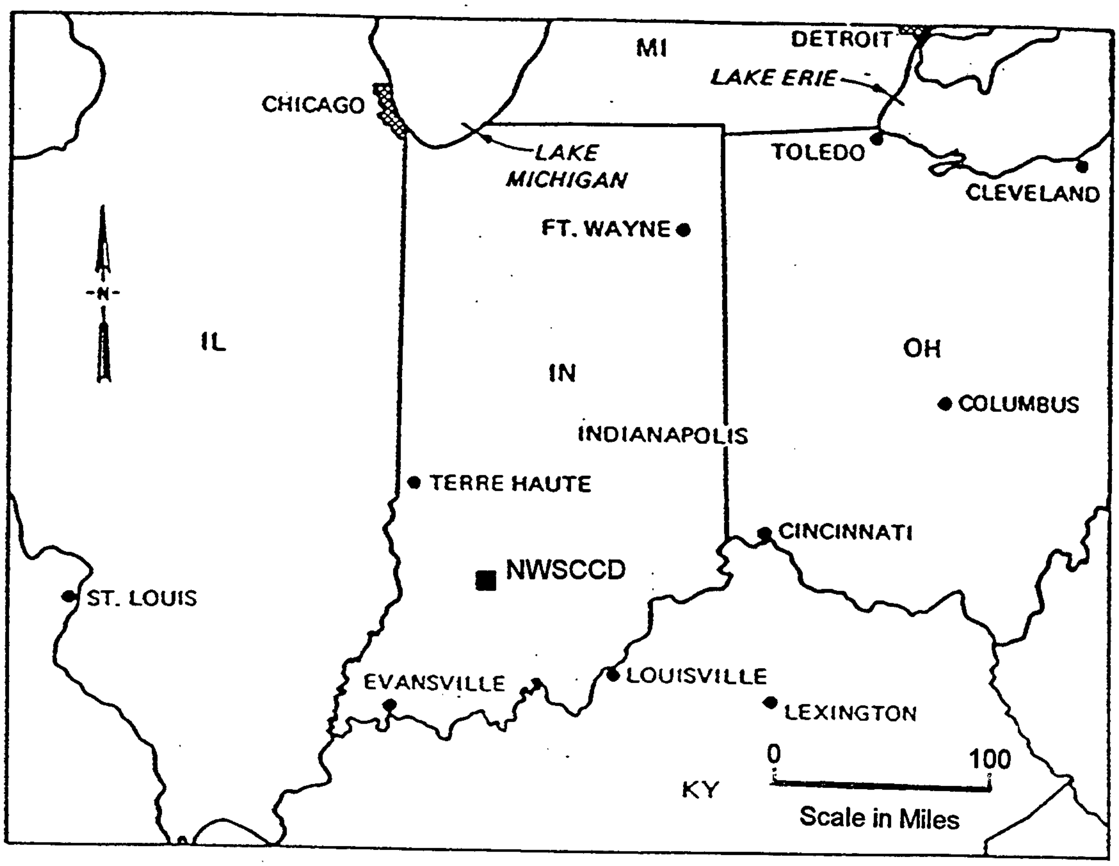


Figure 1. Location of Naval Surface Warfare Center, Crane Division (NSWCCD), Crane, IN

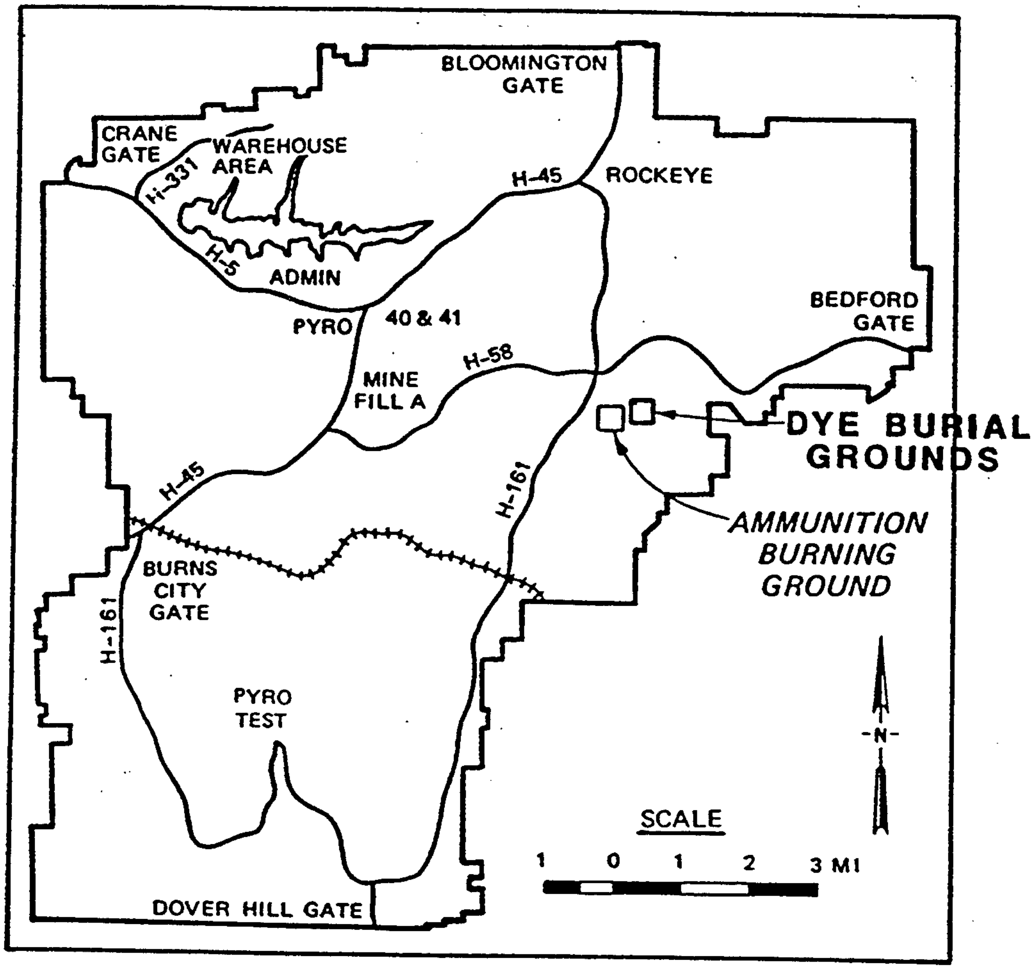


Figure 2. Location of Dye Burial Grounds

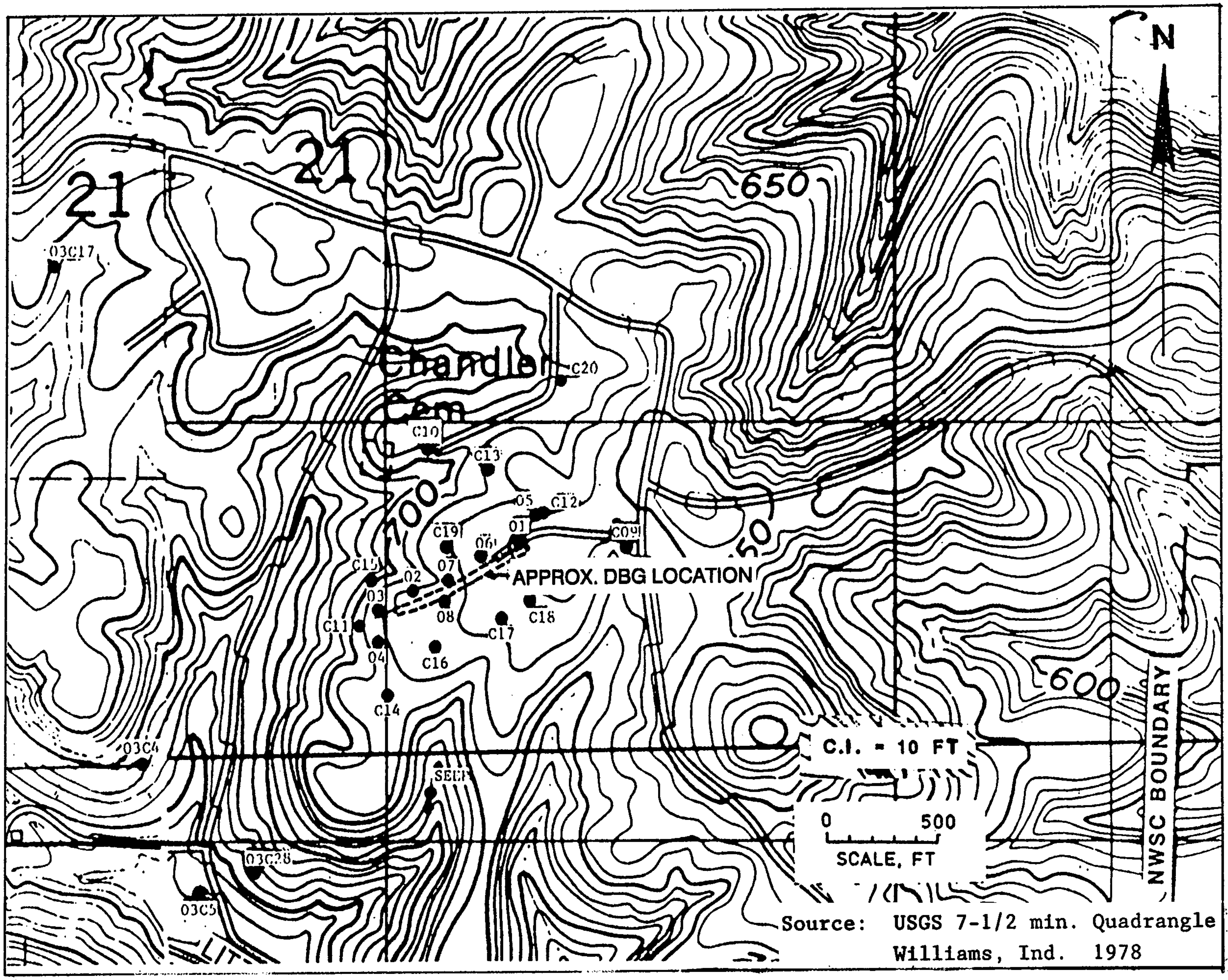


Figure 3. Topography at the Dye Burial Grounds

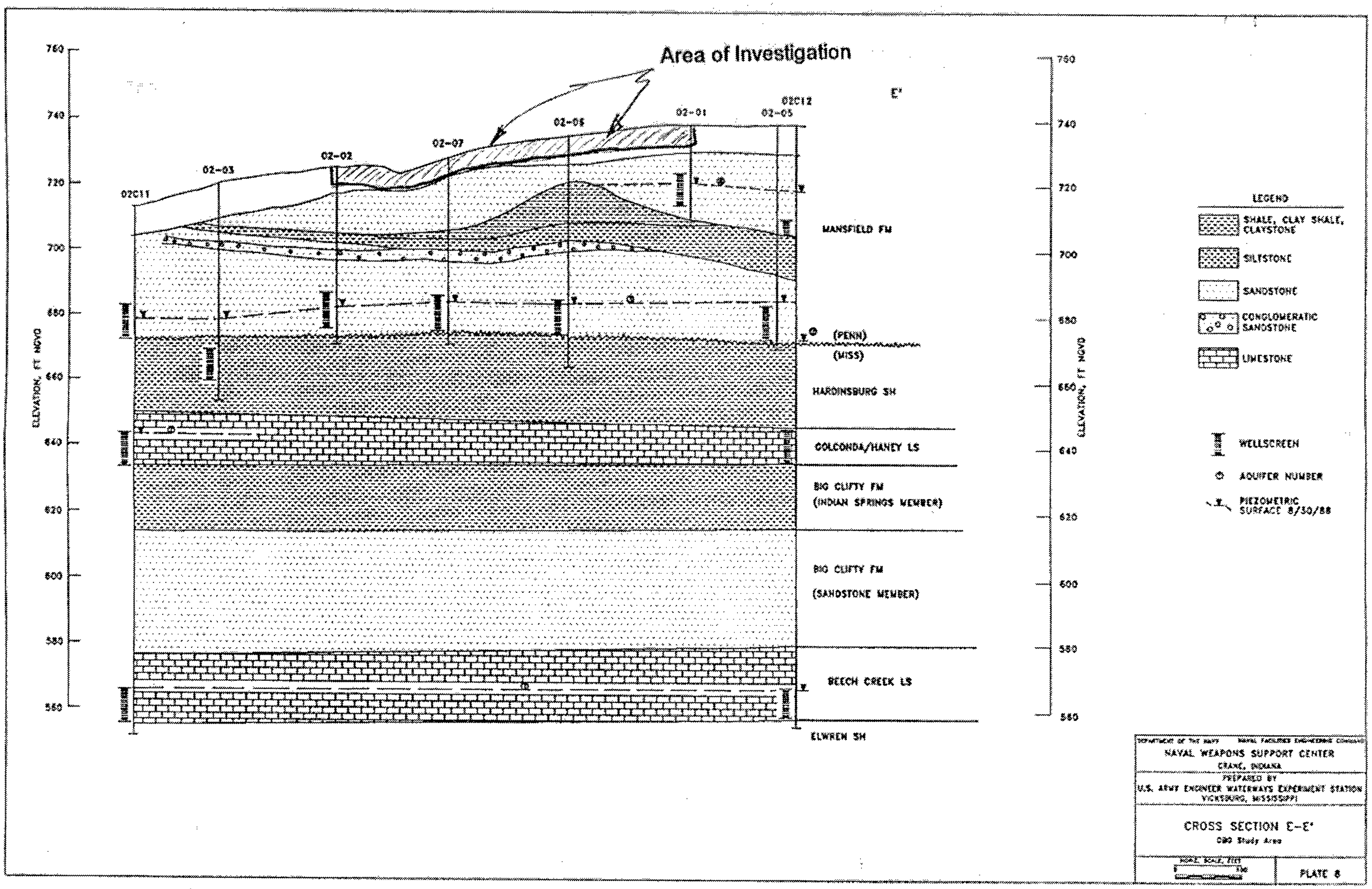


Figure 4. Geologic cross section of the Dye Burial Grounds

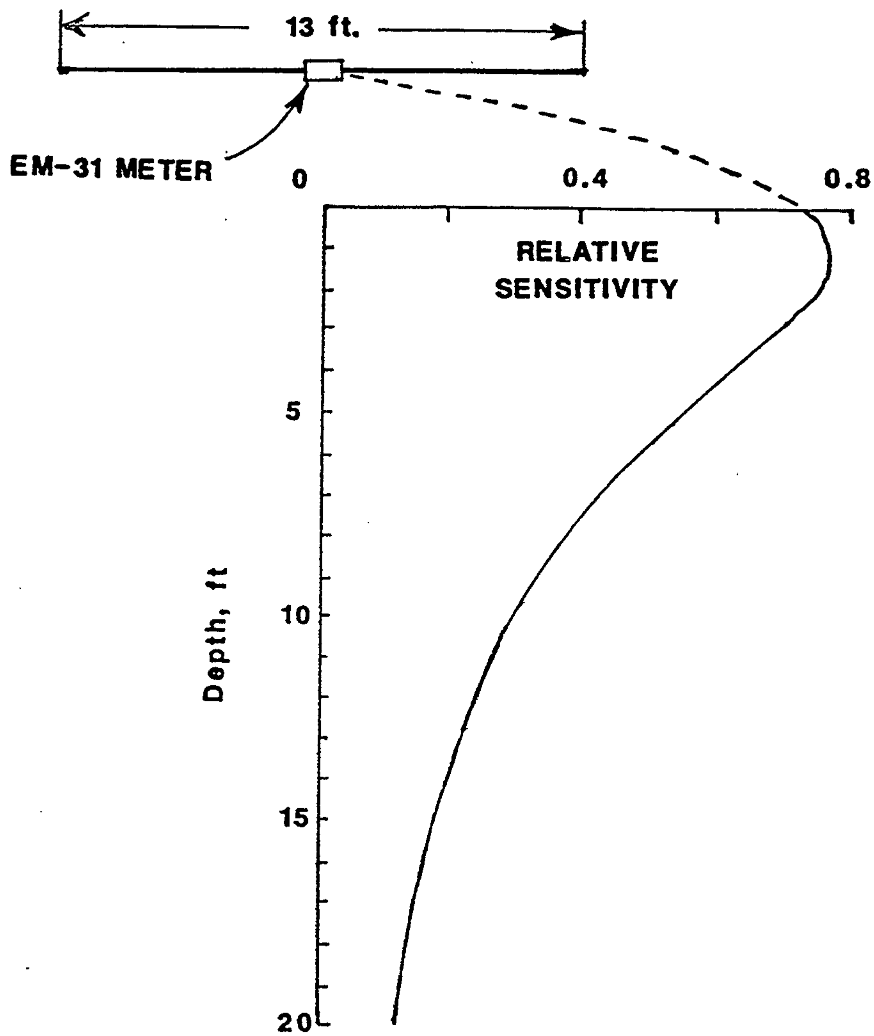


Figure 5. Sensitivity versus depth for the EM31 terrain conductivity meter

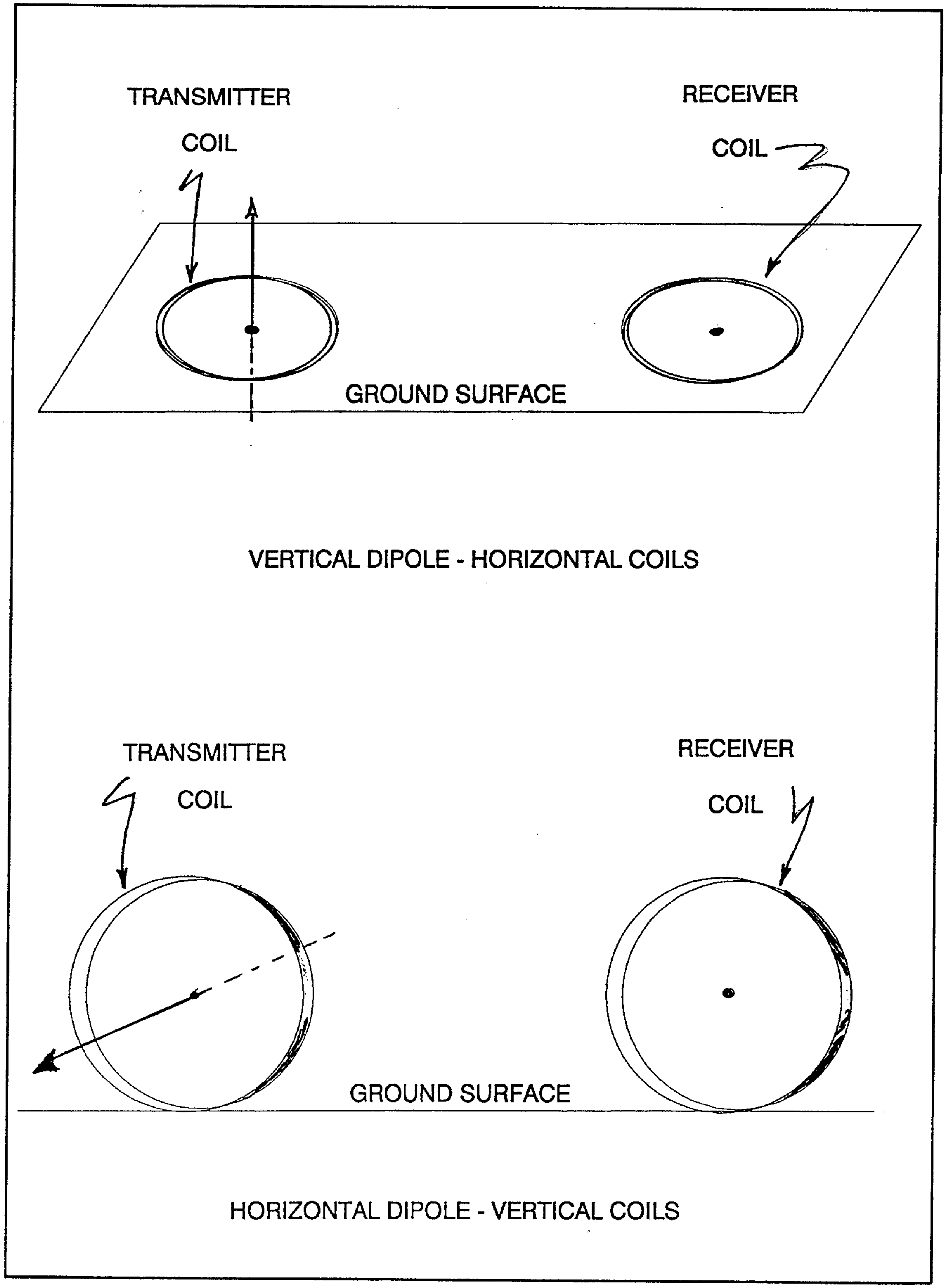


Figure 6. Schematic of EM transmitter and receiver coil orientations

Figure 7. Geonics EM31 terrain conductivity meter

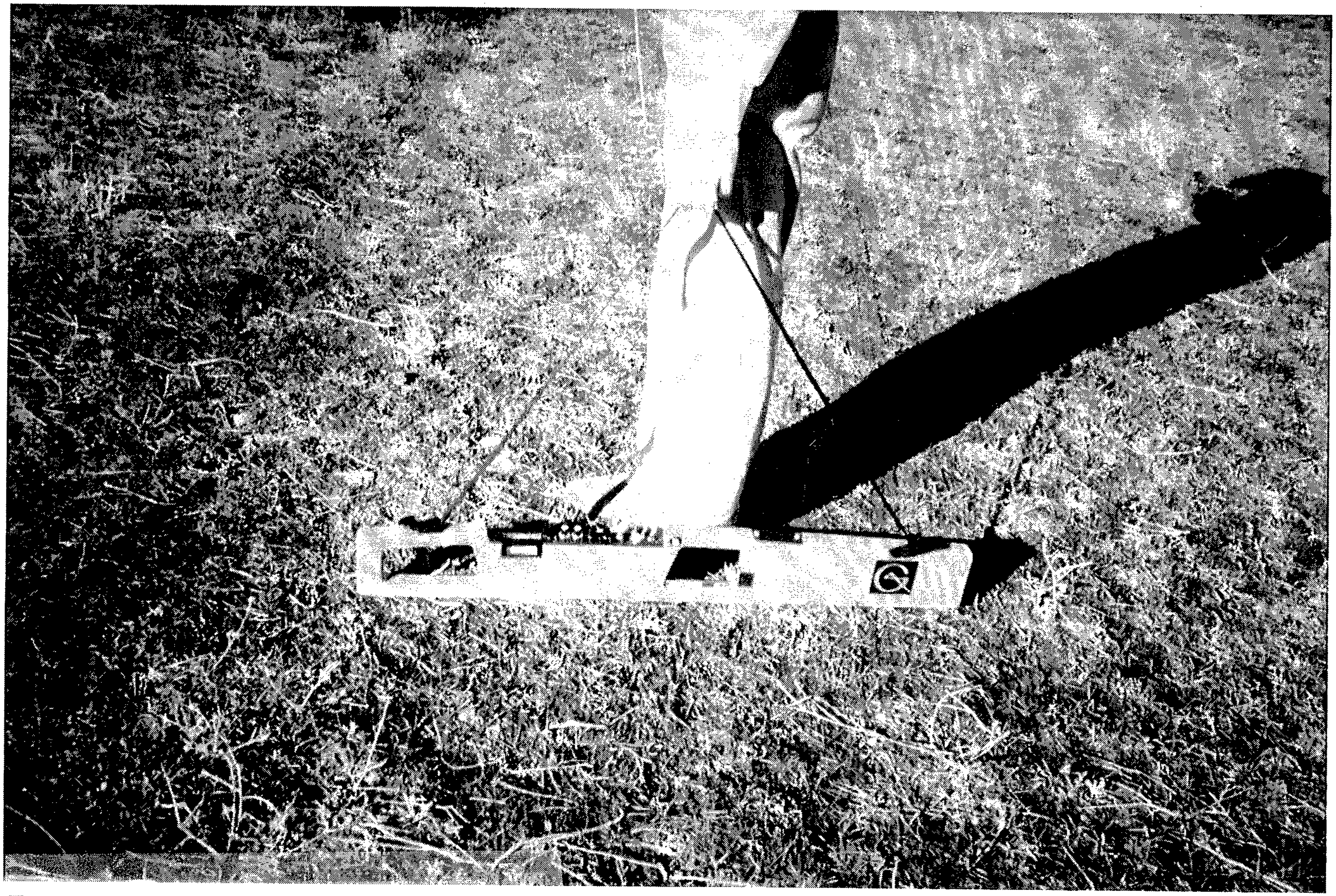


Figure 8. Geonics EM38 terrain conductivity meter

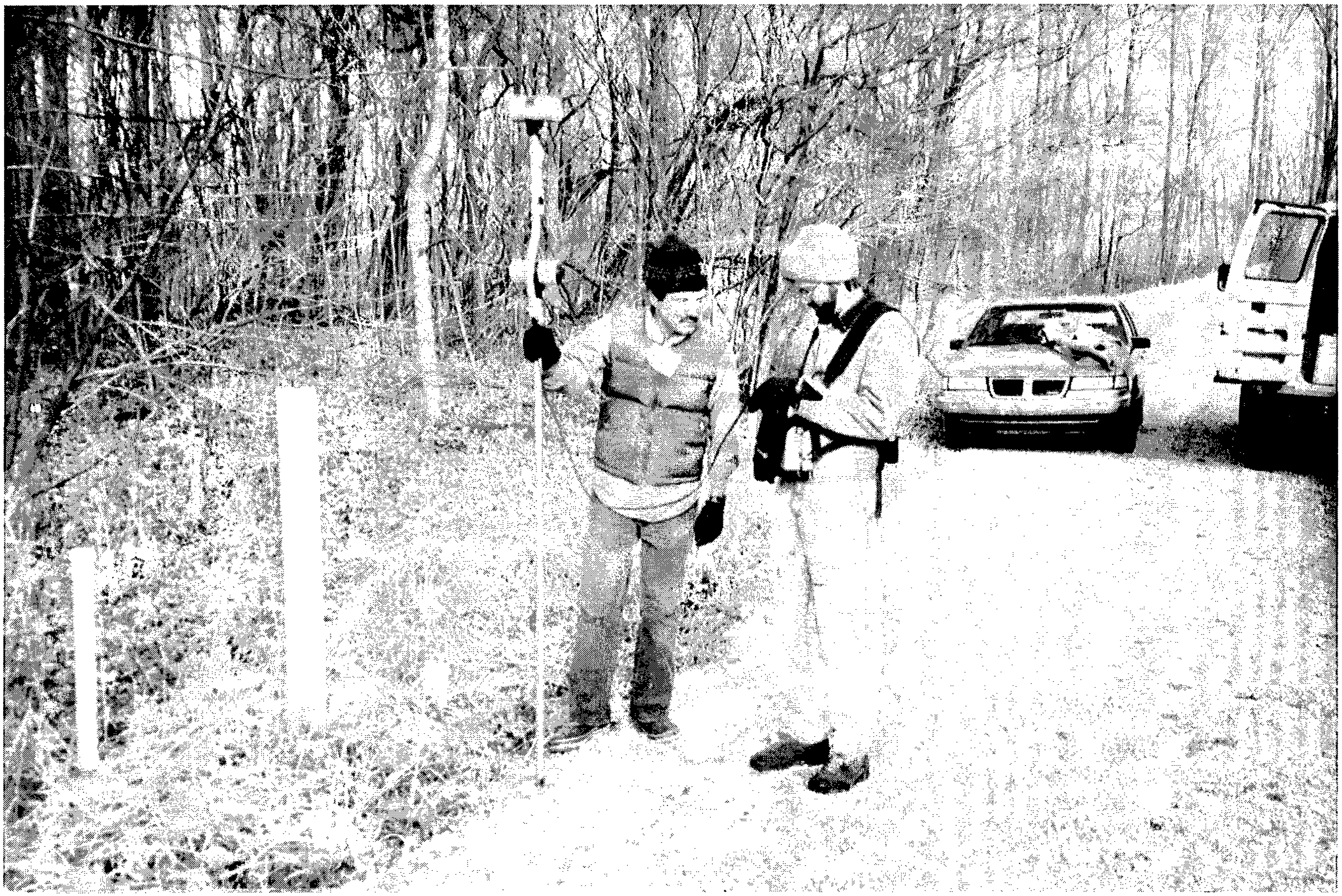


Figure 9. Scintrex MP-3/4 proton-precession magnetometer

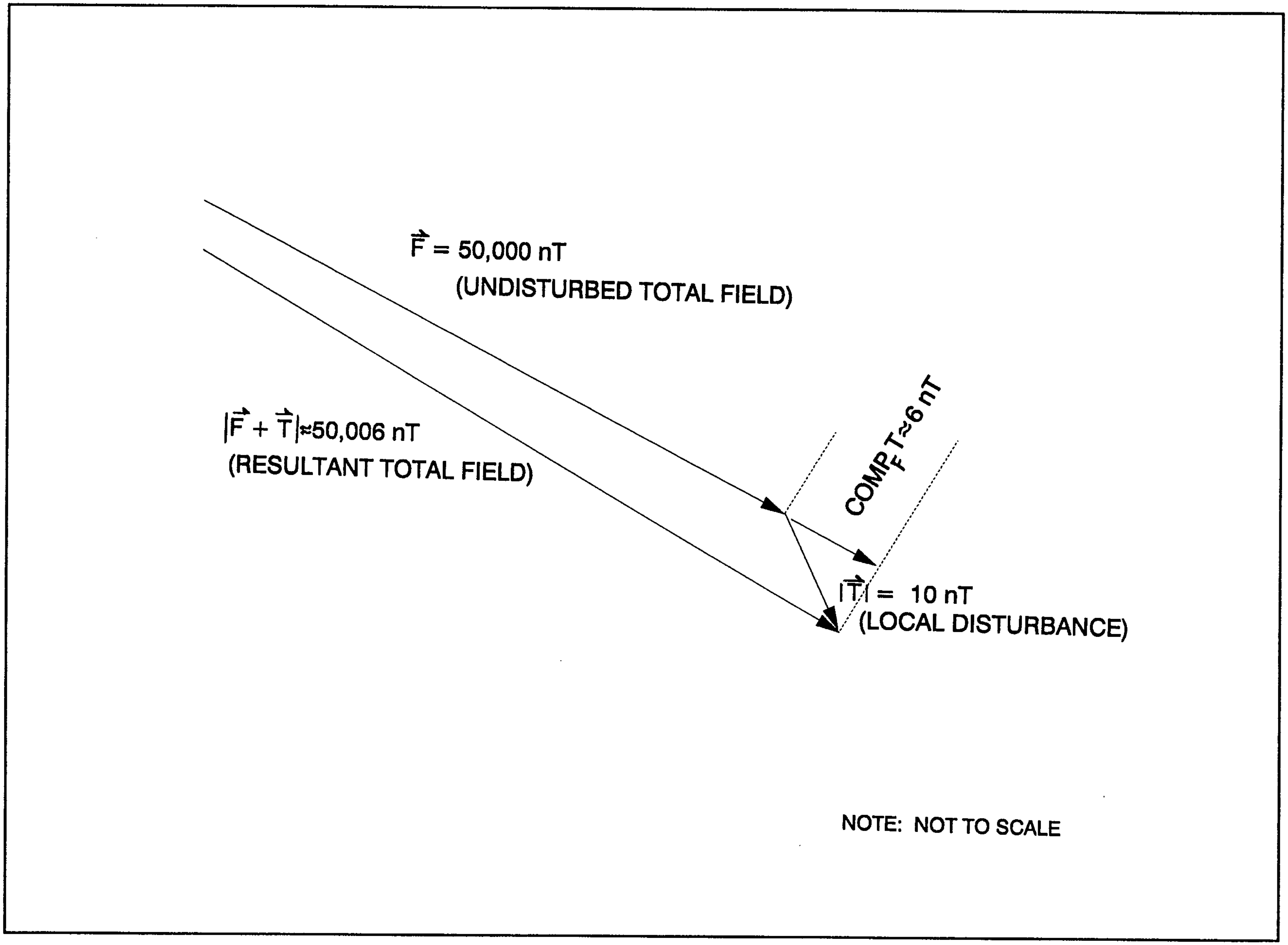


Figure 10. Local perturbation of the total field vector (after Brenier 1973)

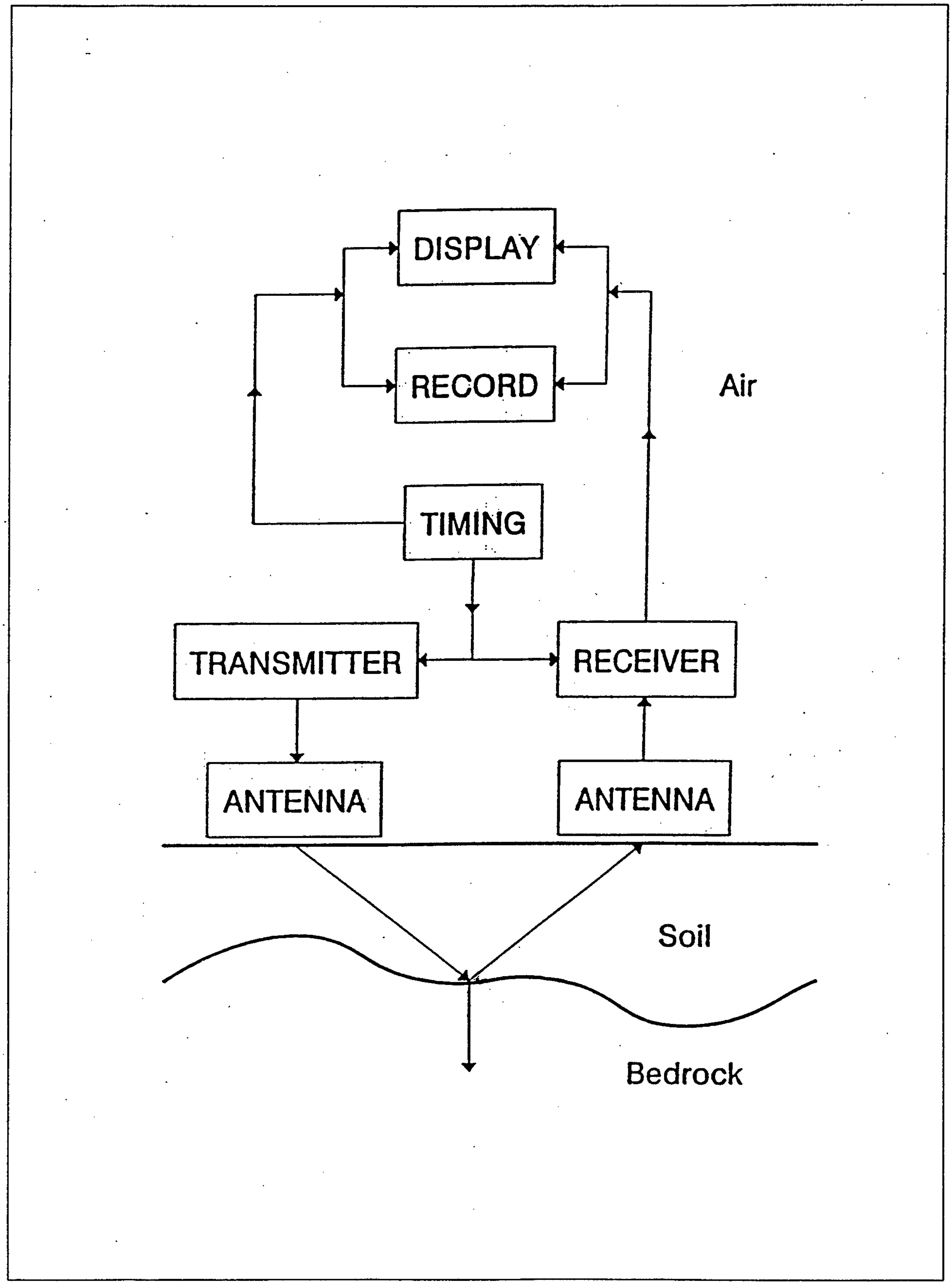


Figure 11. Block diagram depicting main components of a GPR system (after Annan 1992)

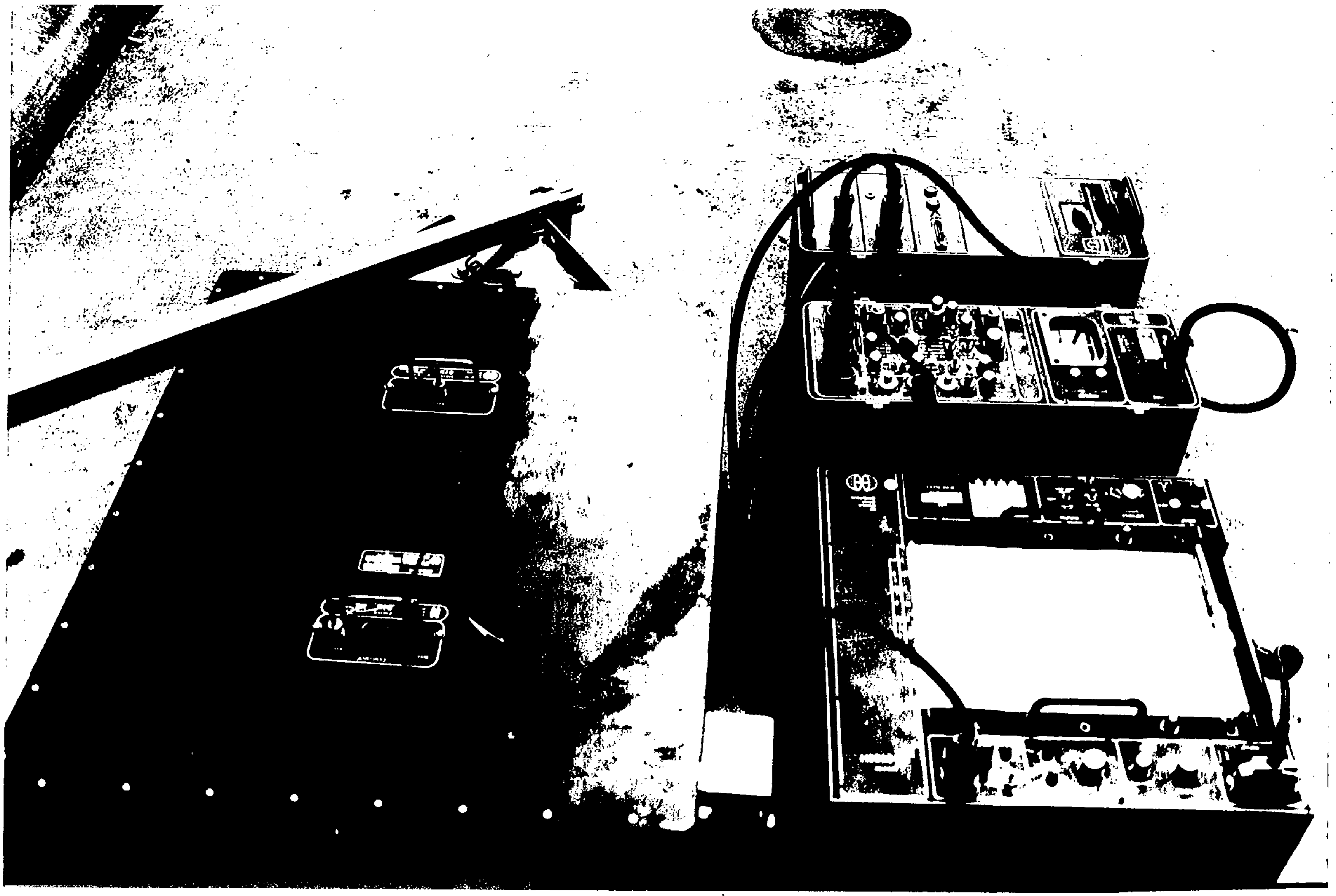


Figure 12. GSSI System 8 GPR with 300 Mhz antenna

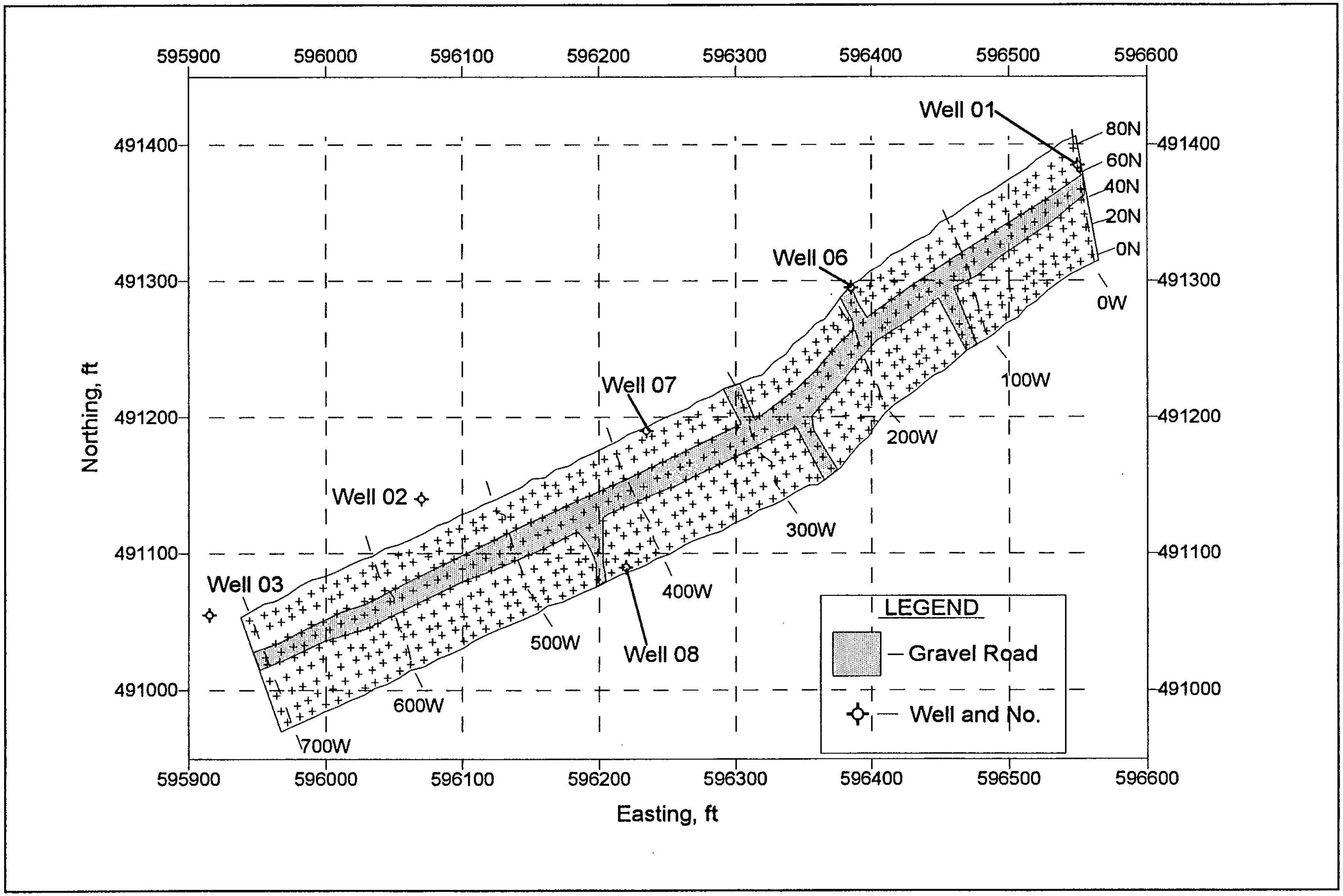


Figure 13. Geophysical survey grid for the Dye Burial Grounds

Figure 14. Digital data logger connected to an EM31 terrain conductivity meter

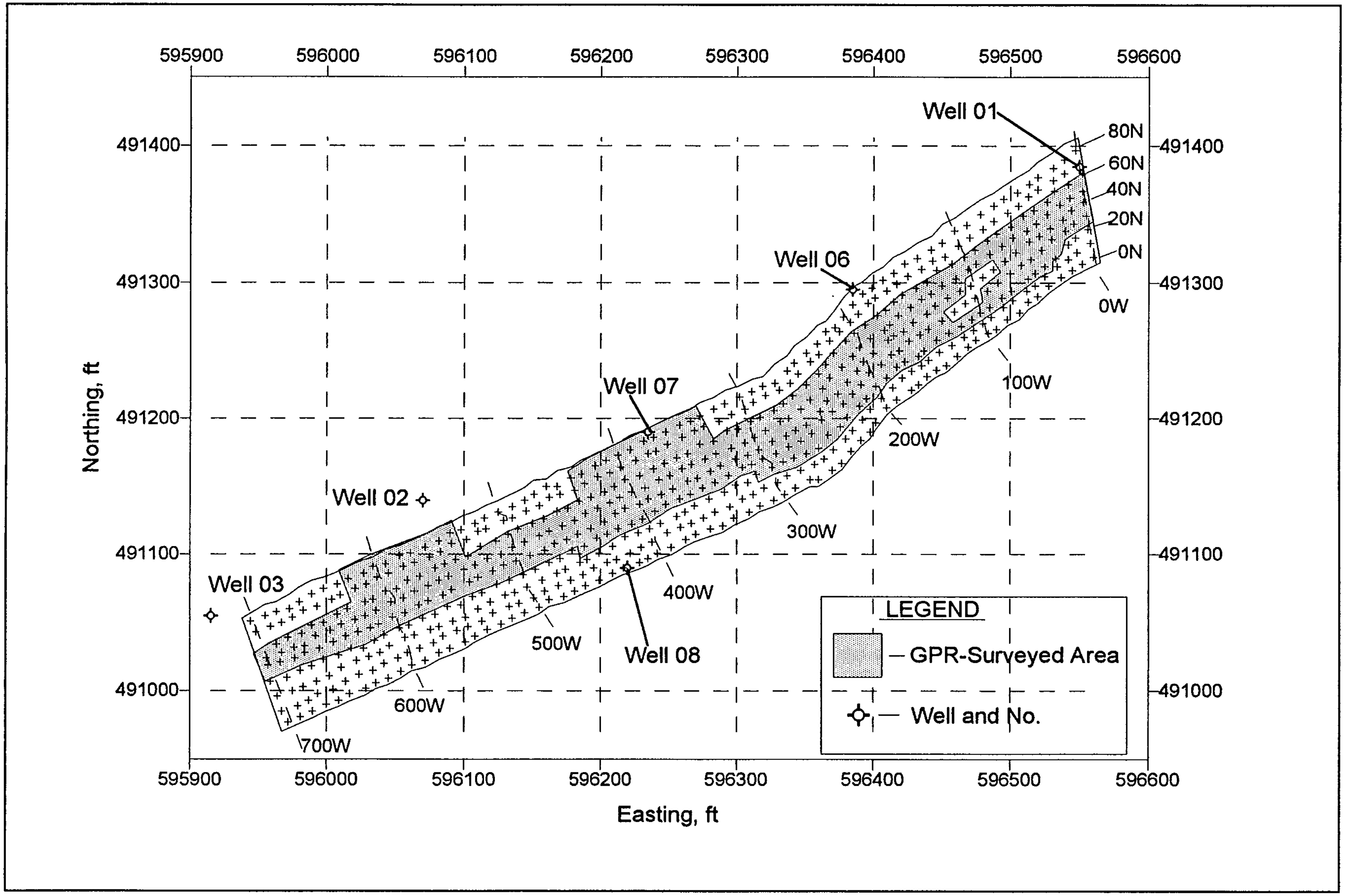


Figure 15. Area of Dye Burial Grounds surveyed with GPR

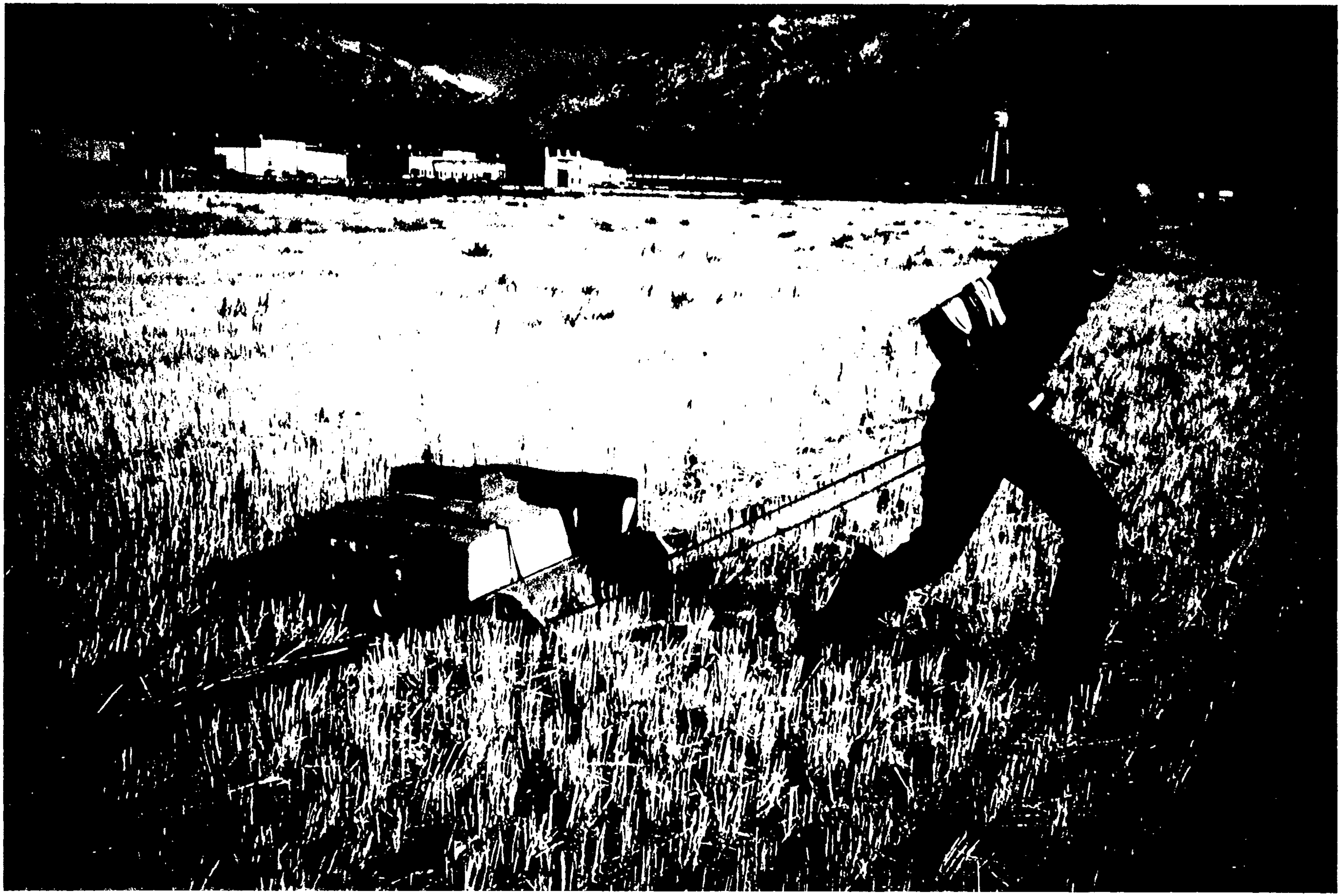


Figure 16. Typical GPR field survey

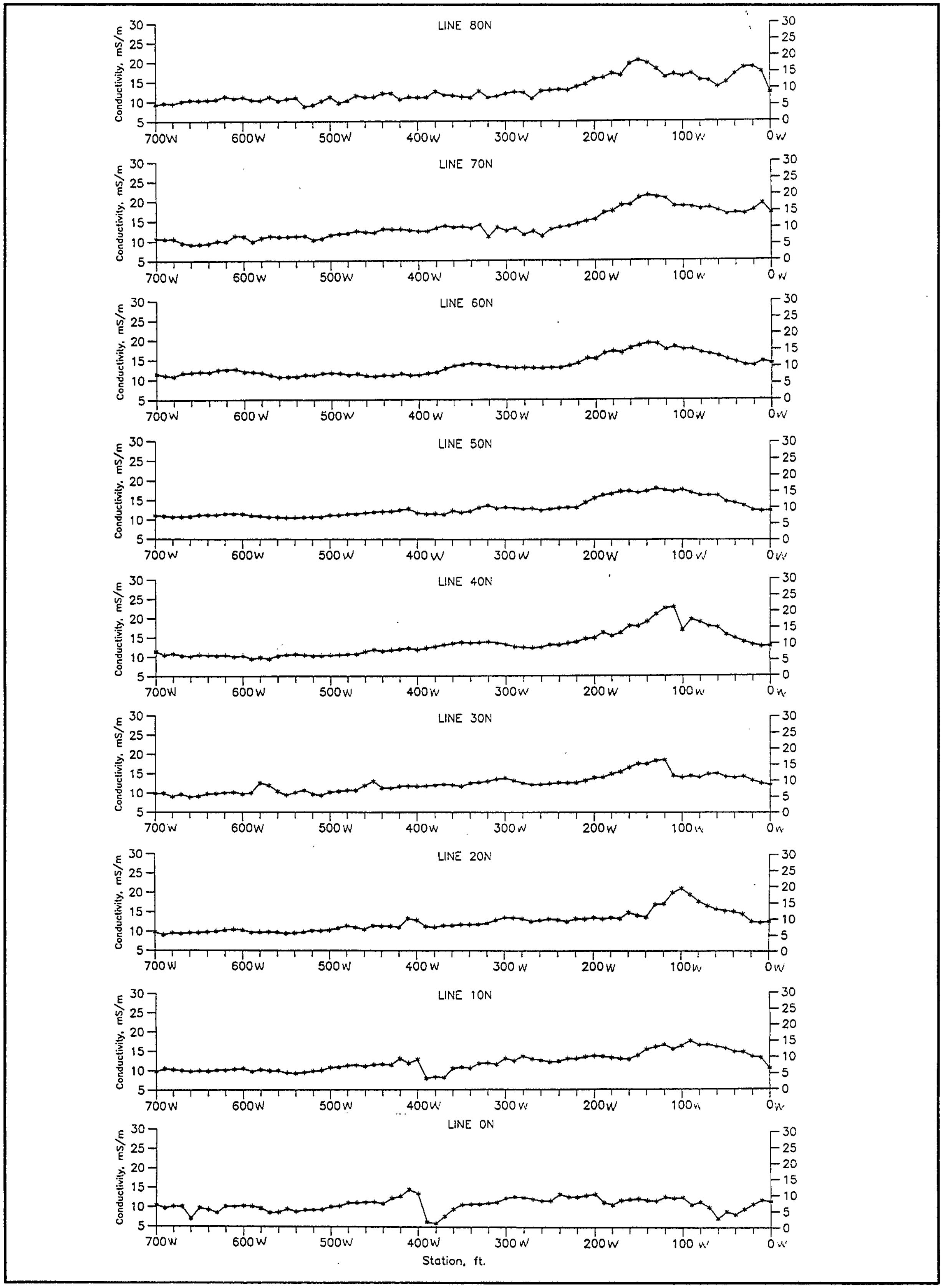


Figure 17. EM31 conductivity test results, profile lines

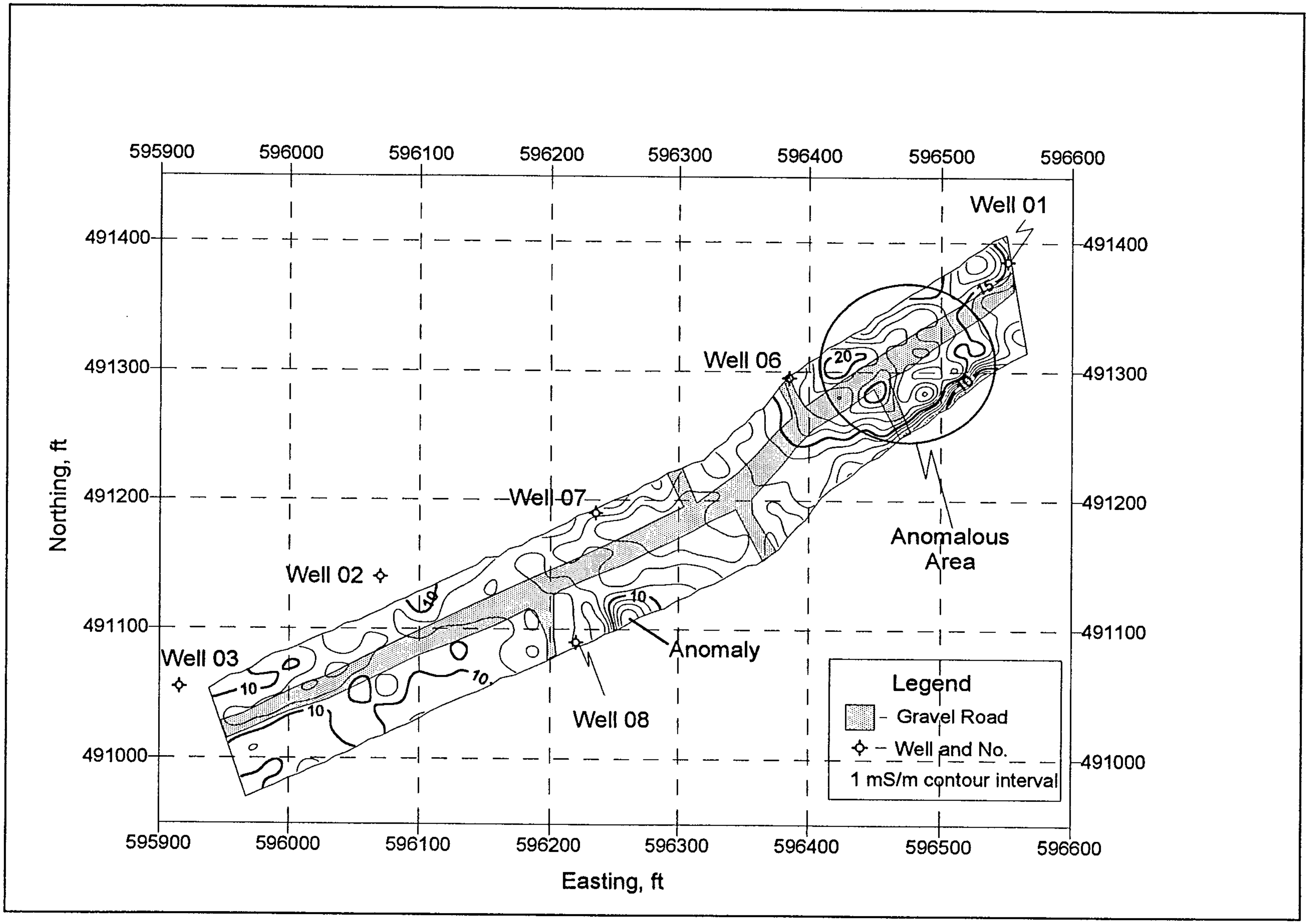


Figure 18. EM31 conductivity test results

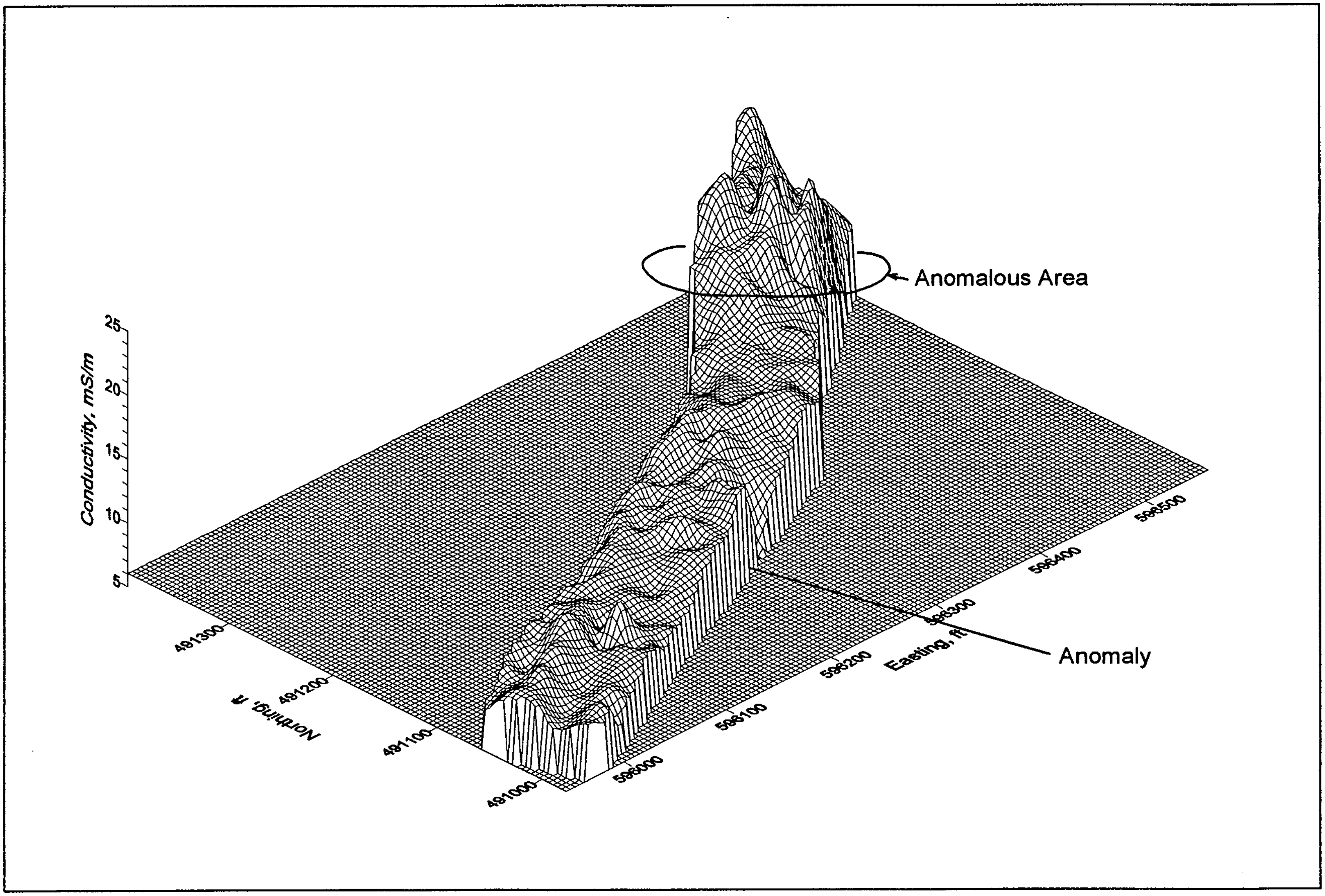


Figure 19. EM31 conductivity test results, block diagram

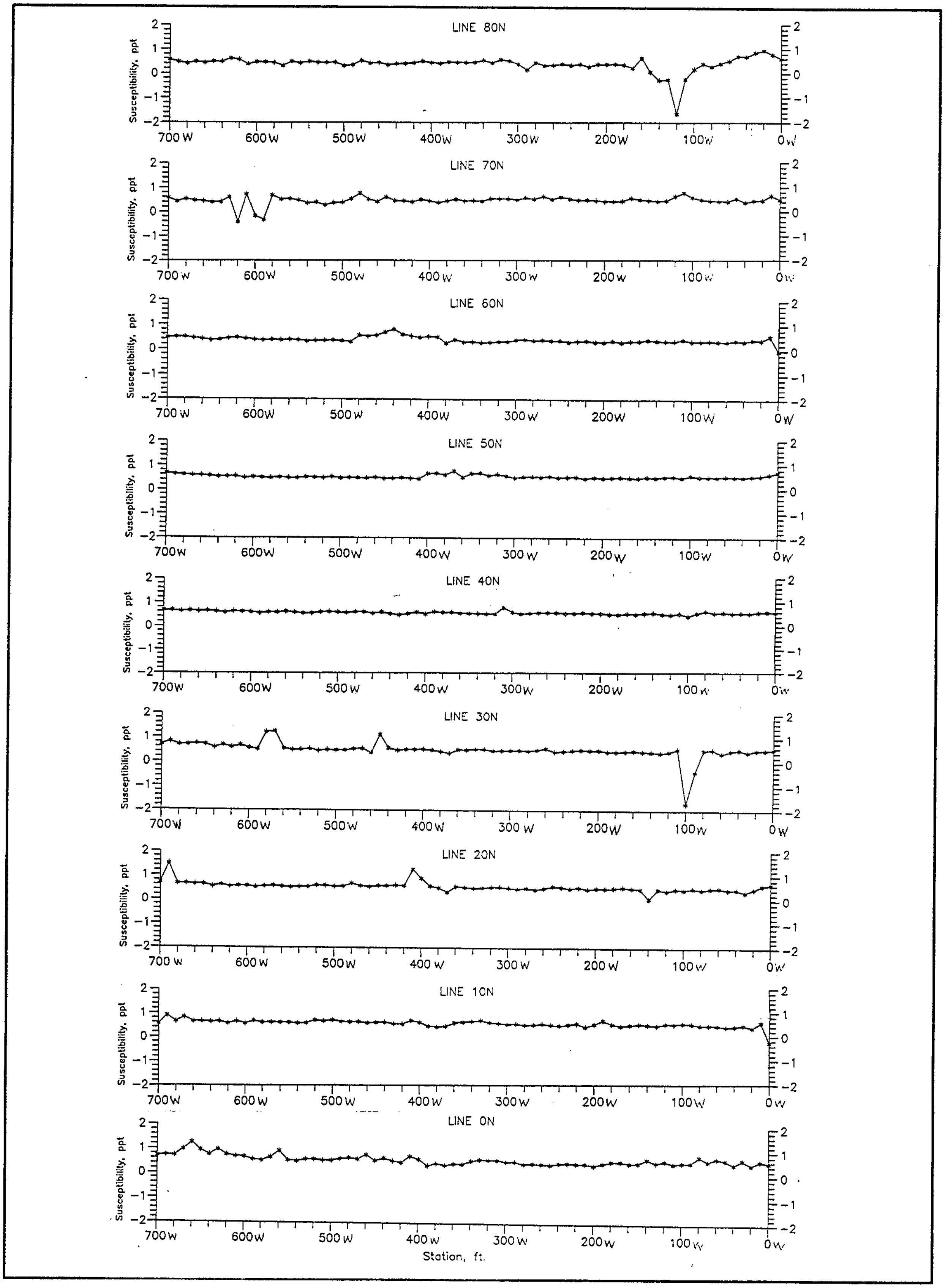


Figure 20. EM31 inphase test results, profile lines

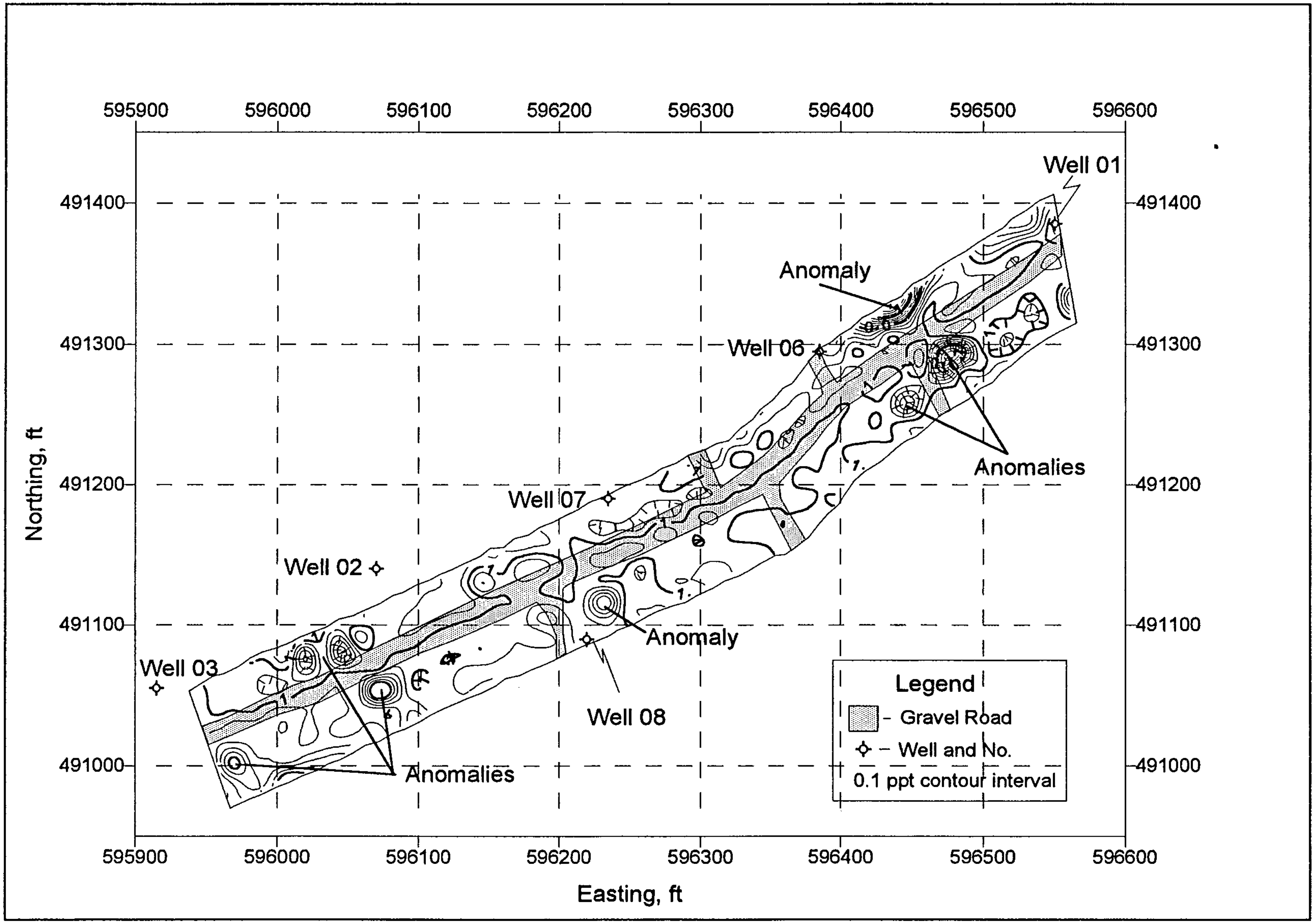


Figure 21. EM31 inphase test results

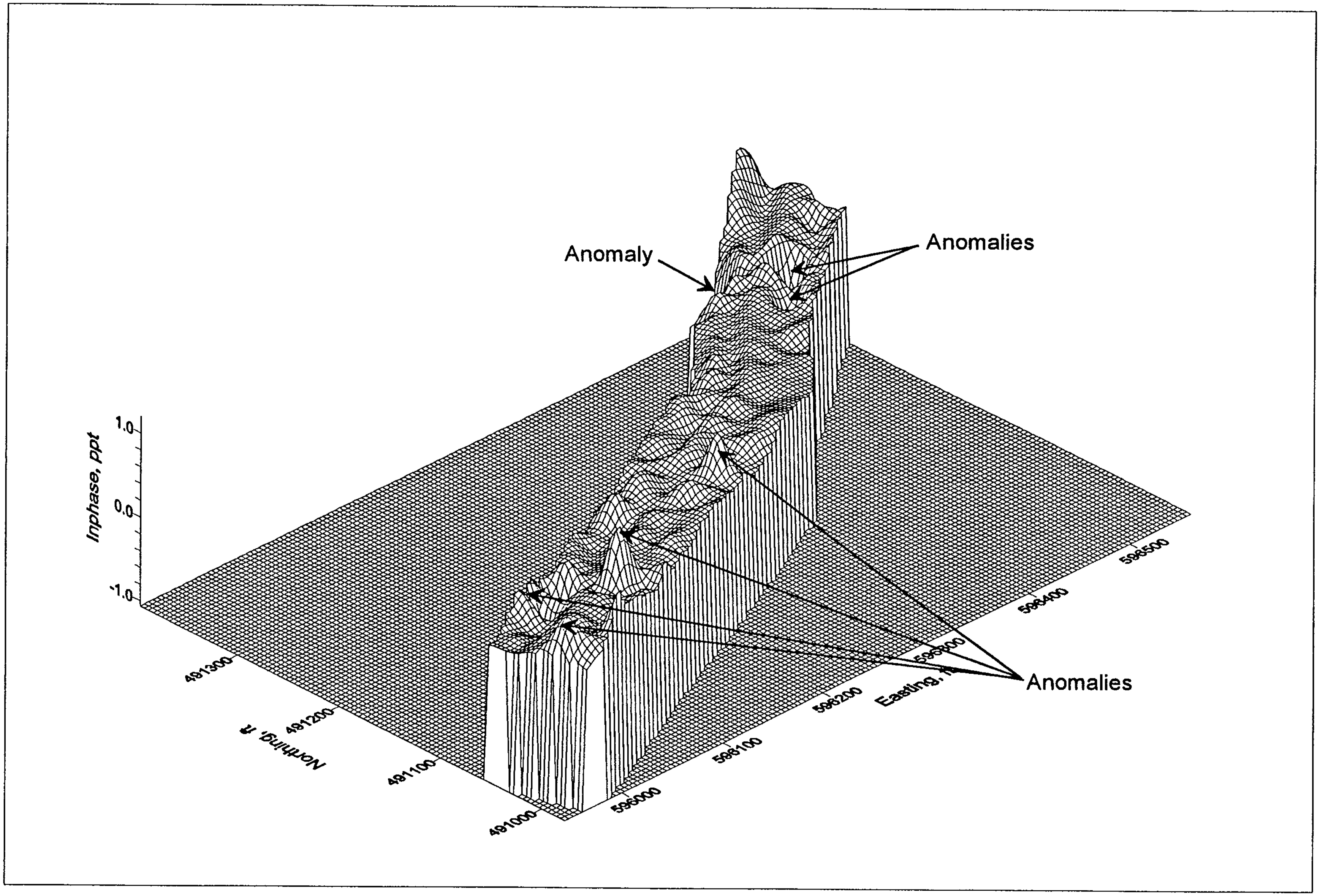


Figure 22. EM31 inphase test results, block diagram

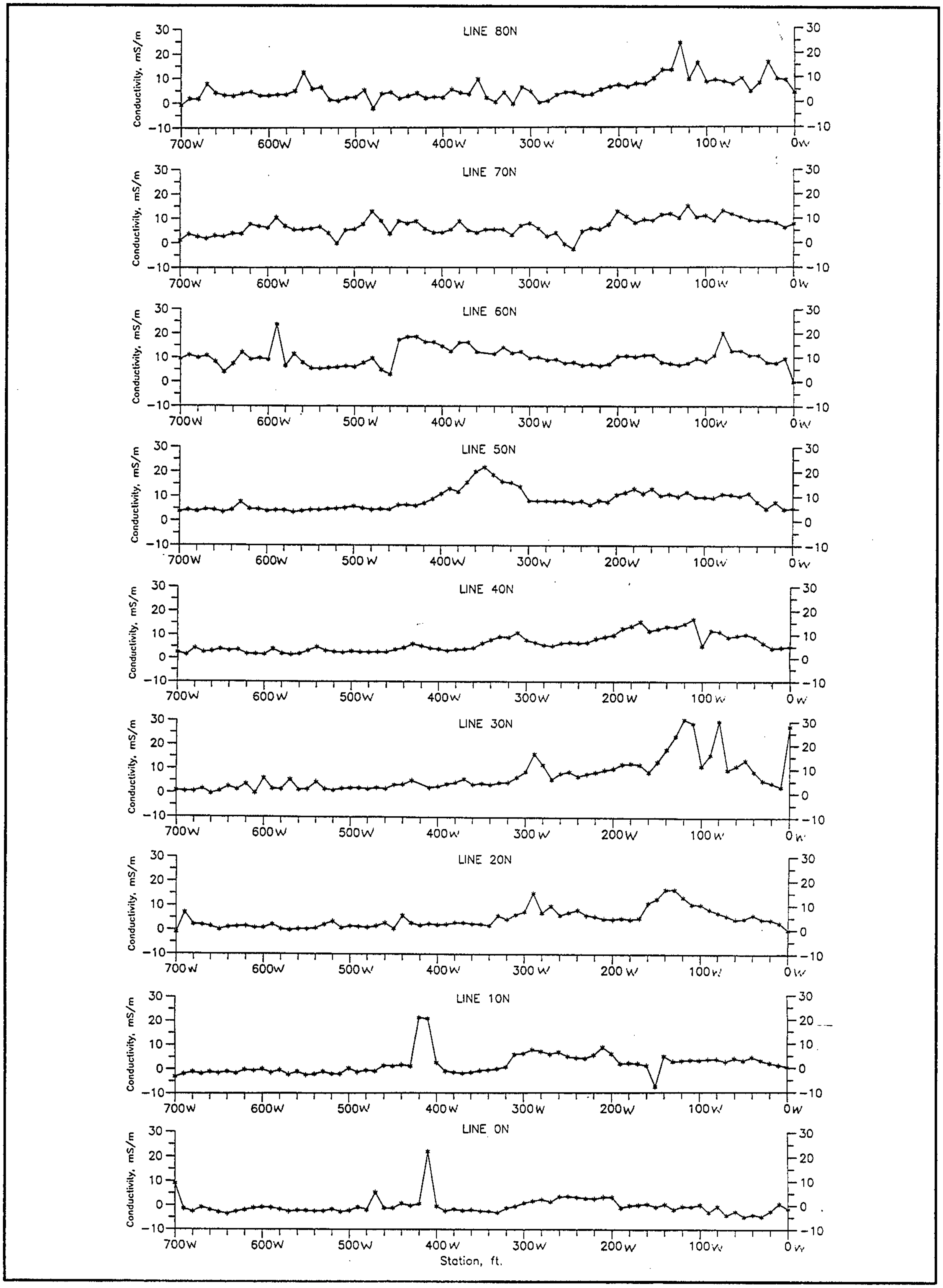


Figure 23. EM38 conductivity test results, profile lines

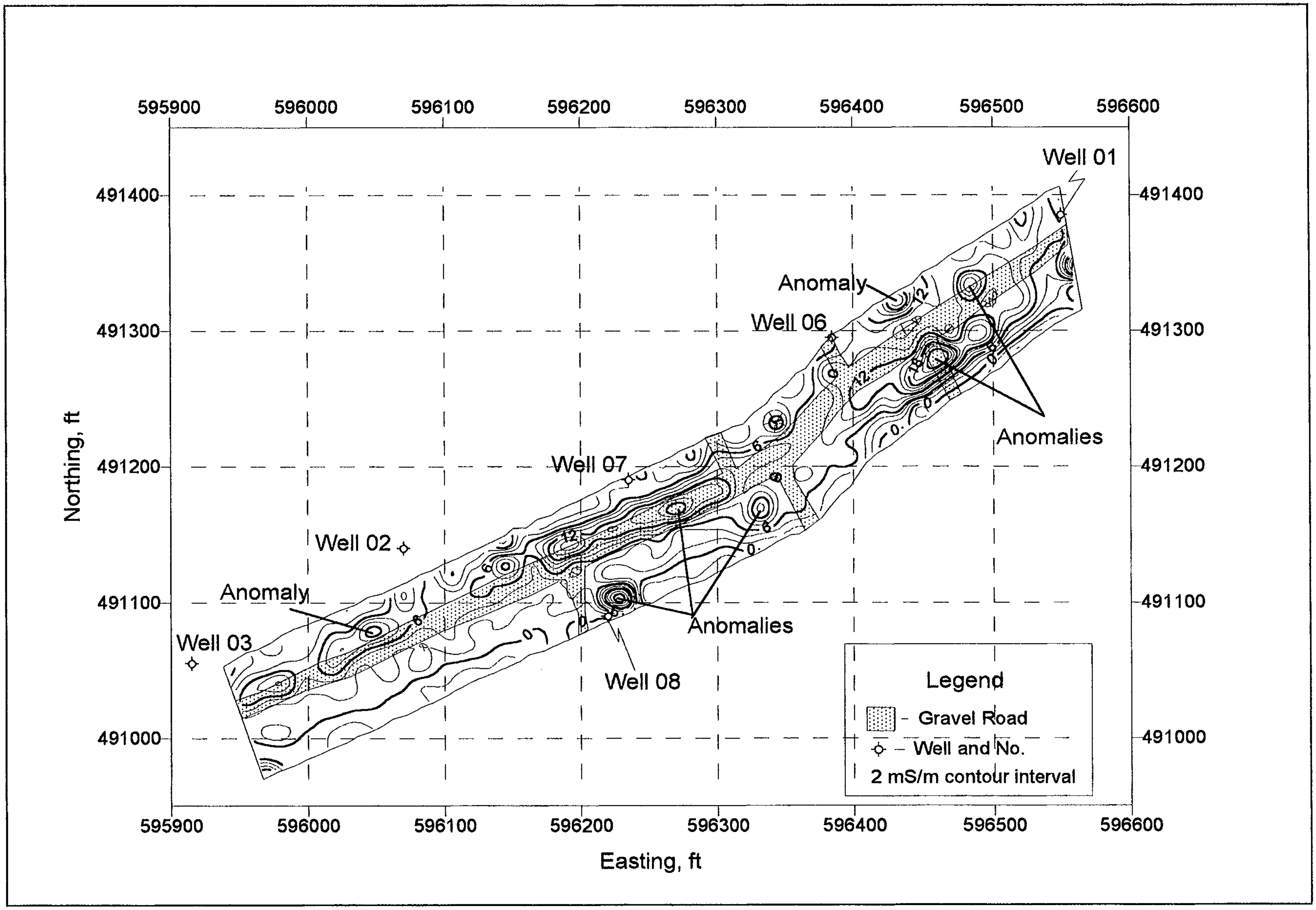


Figure 24. EM38 conductivity test results

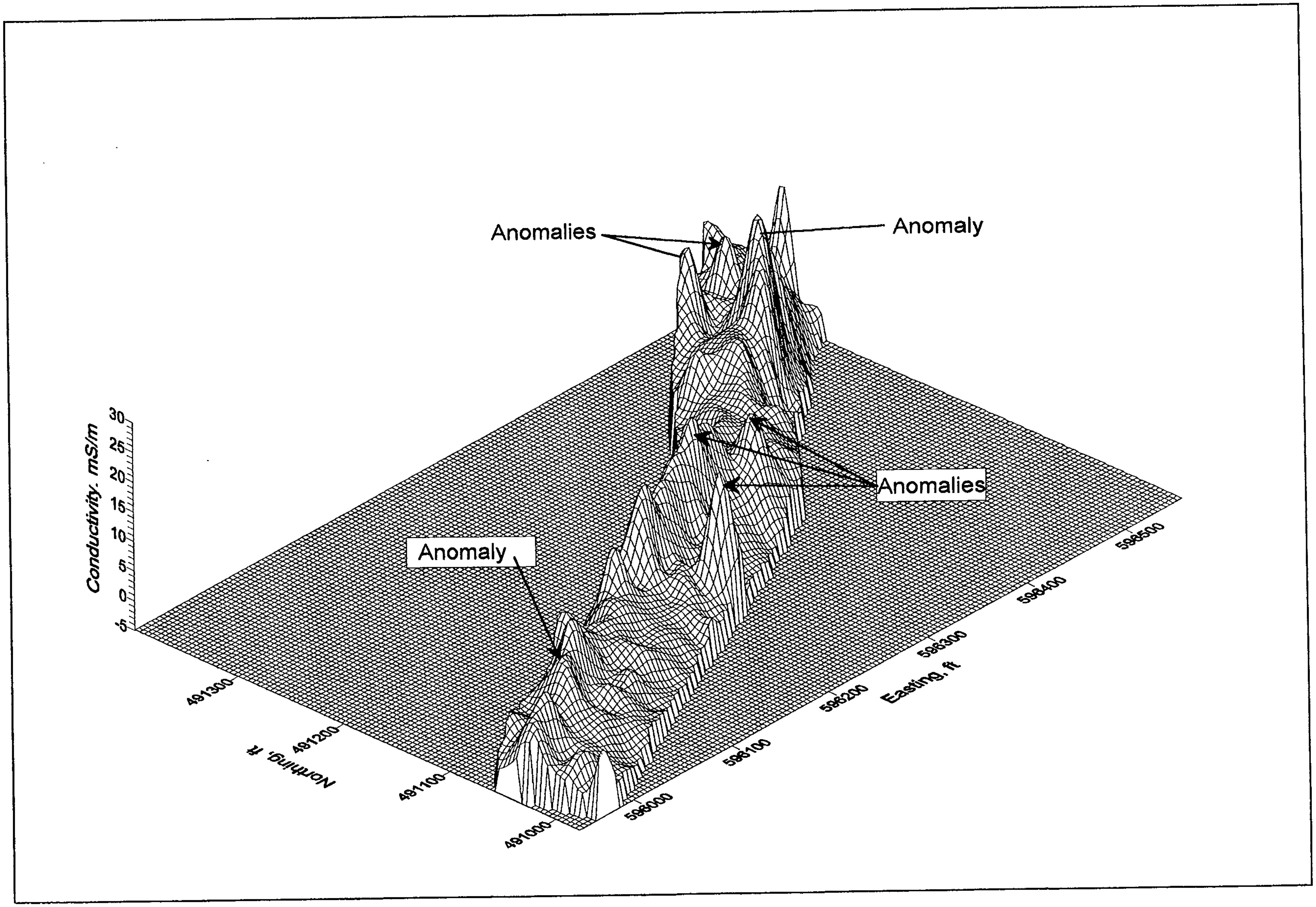


Figure 25. EM38 conductivity test results, block diagram

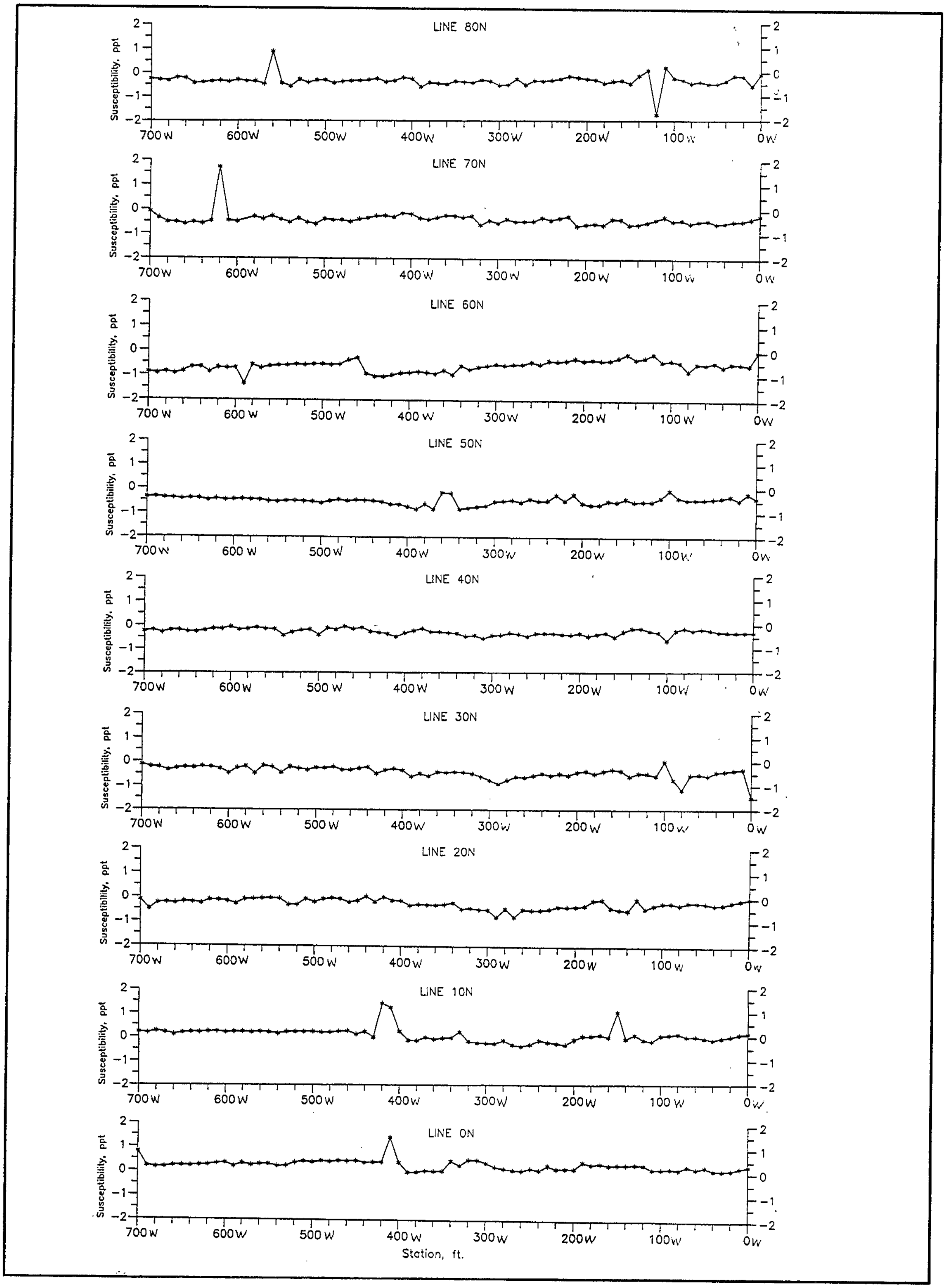


Figure 26. EM38 inphase test results, profile lines

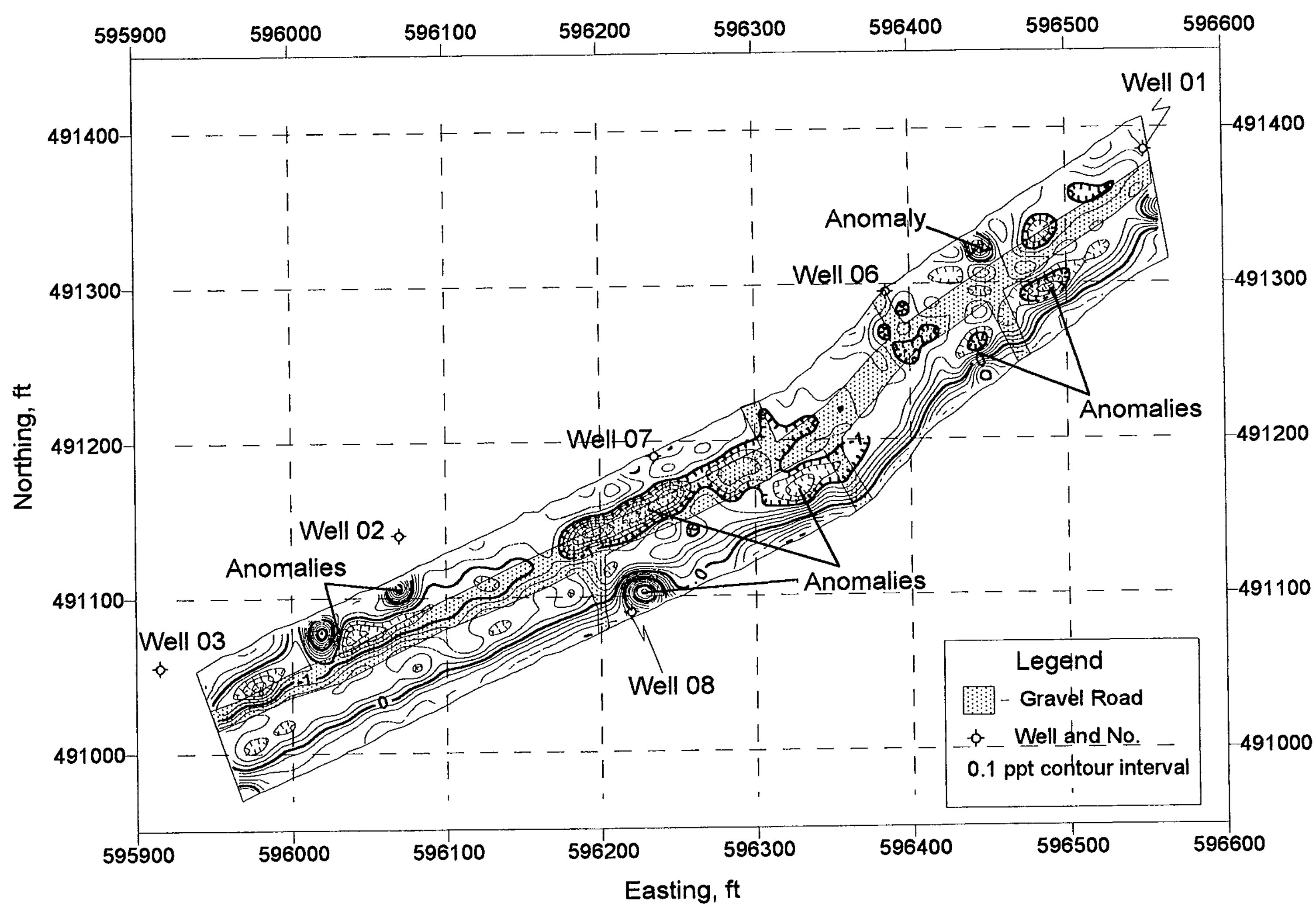


Figure 27. EM38 inphase test results

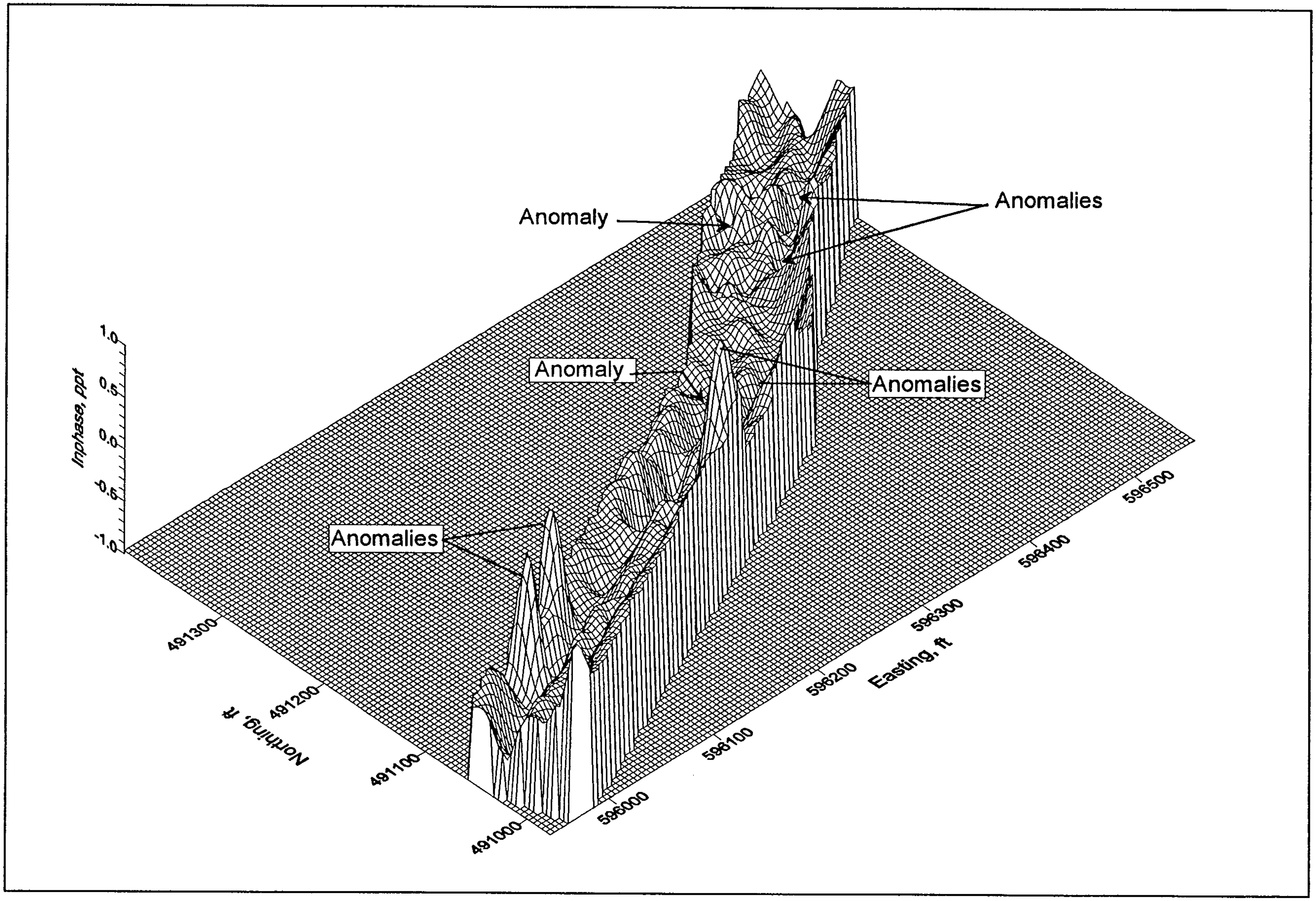


Figure 28. EM38 inphase test results, block diagram

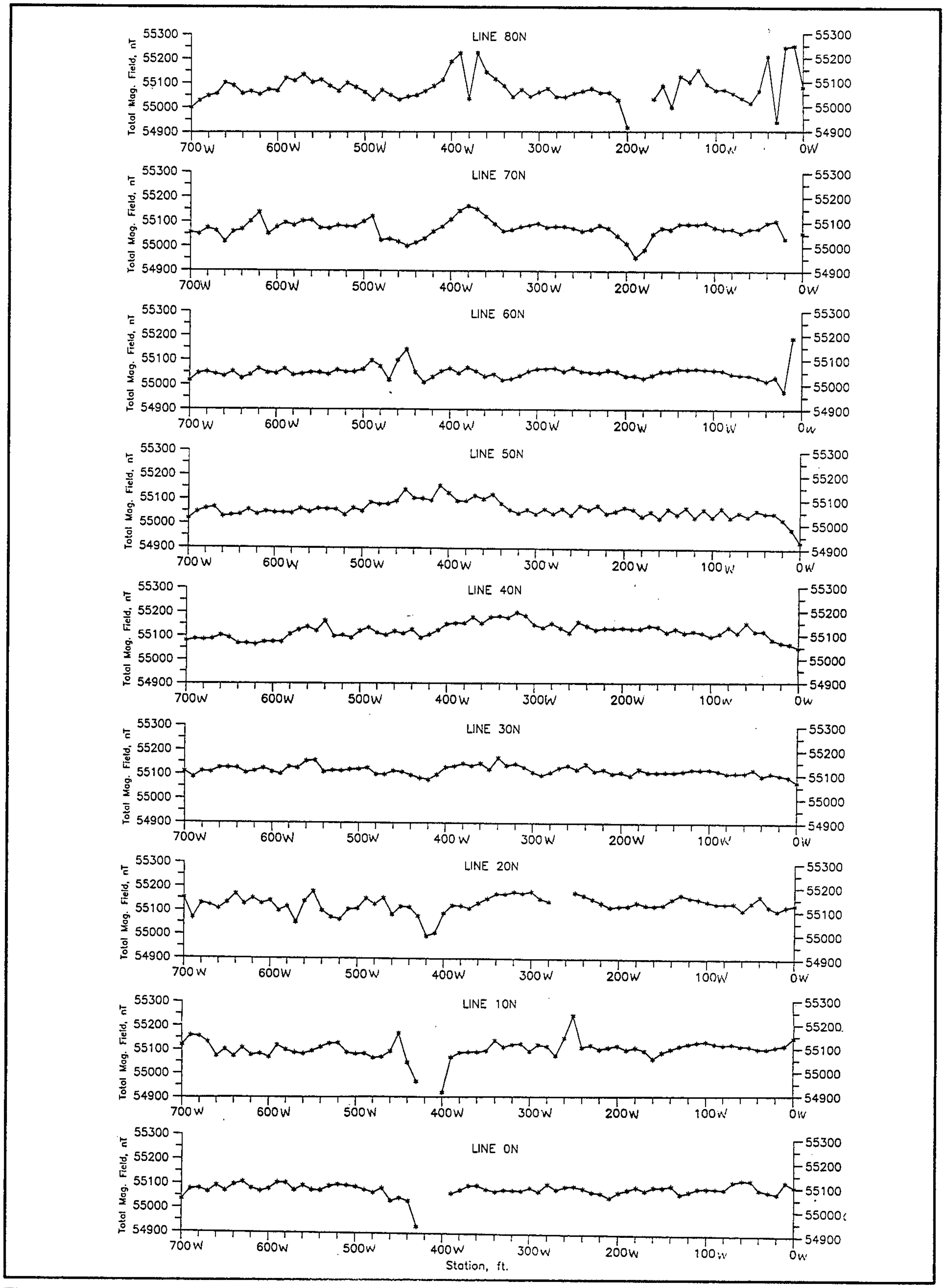


Figure 29. Total magnetic field test results, profile lines

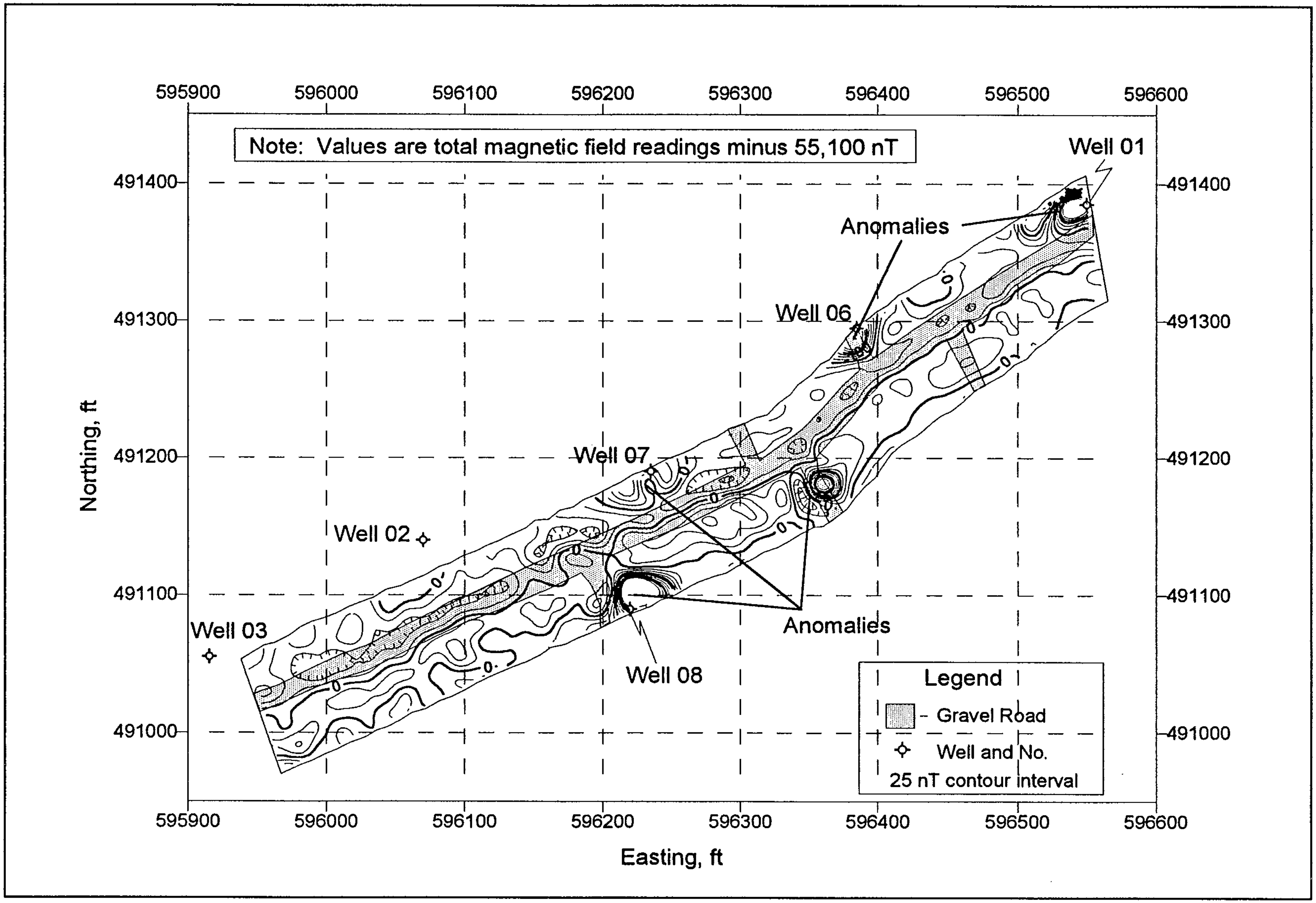


Figure 30. Total magnetic field test results

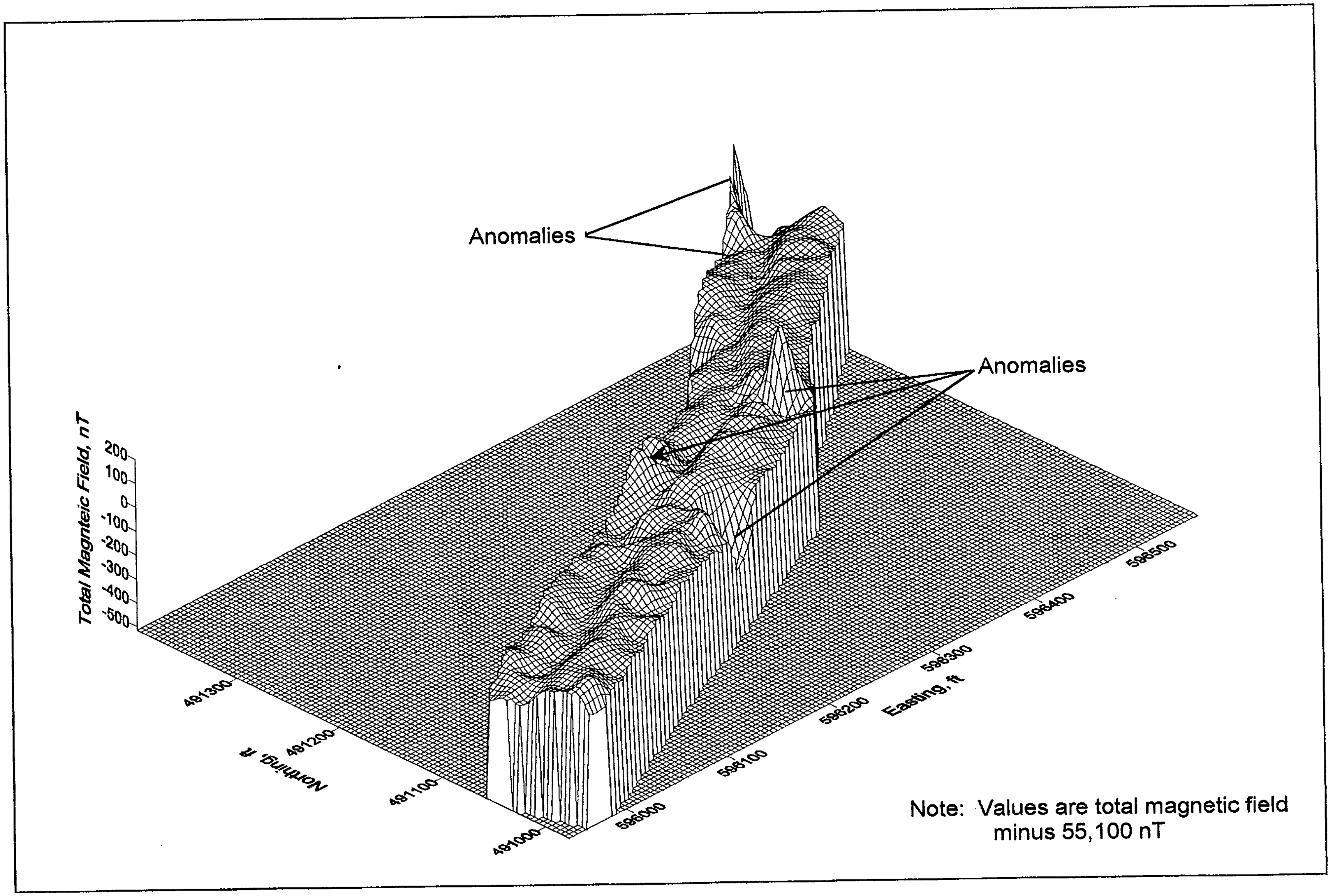


Figure 31. Total magnetic field test results, block diagram

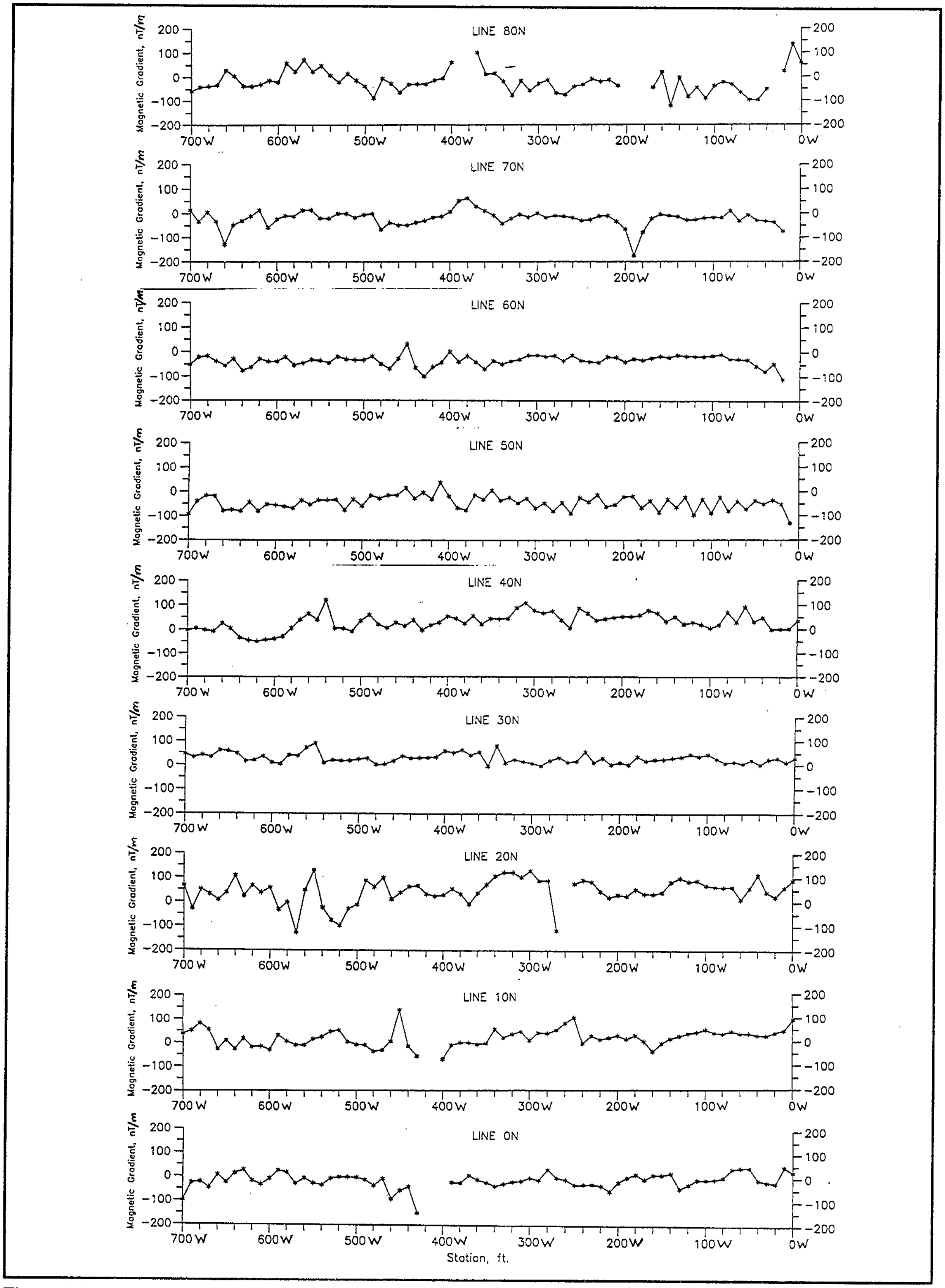


Figure 32. Magnetic gradient test results, profile lines

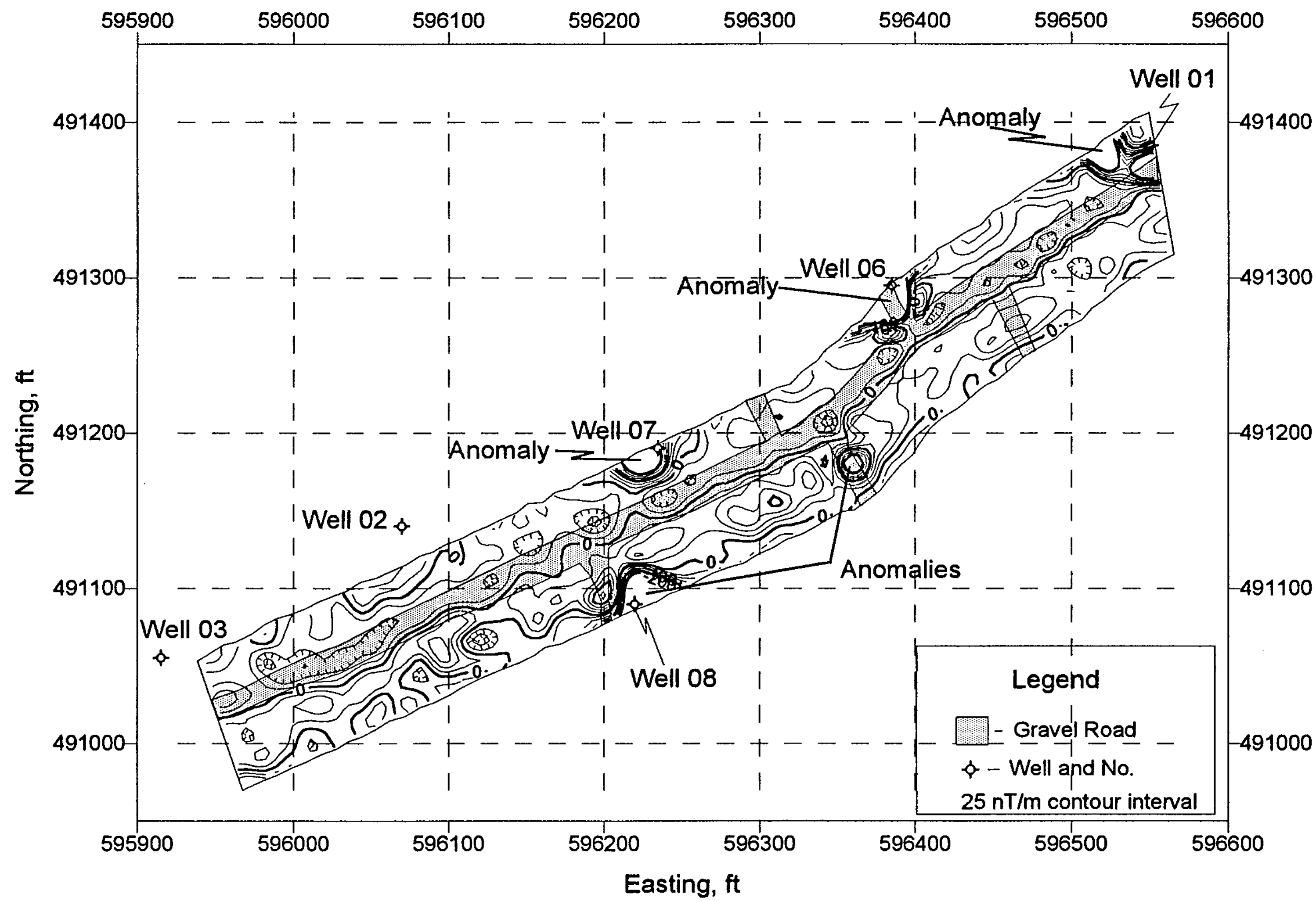


Figure 33. Magnetic gradient test results

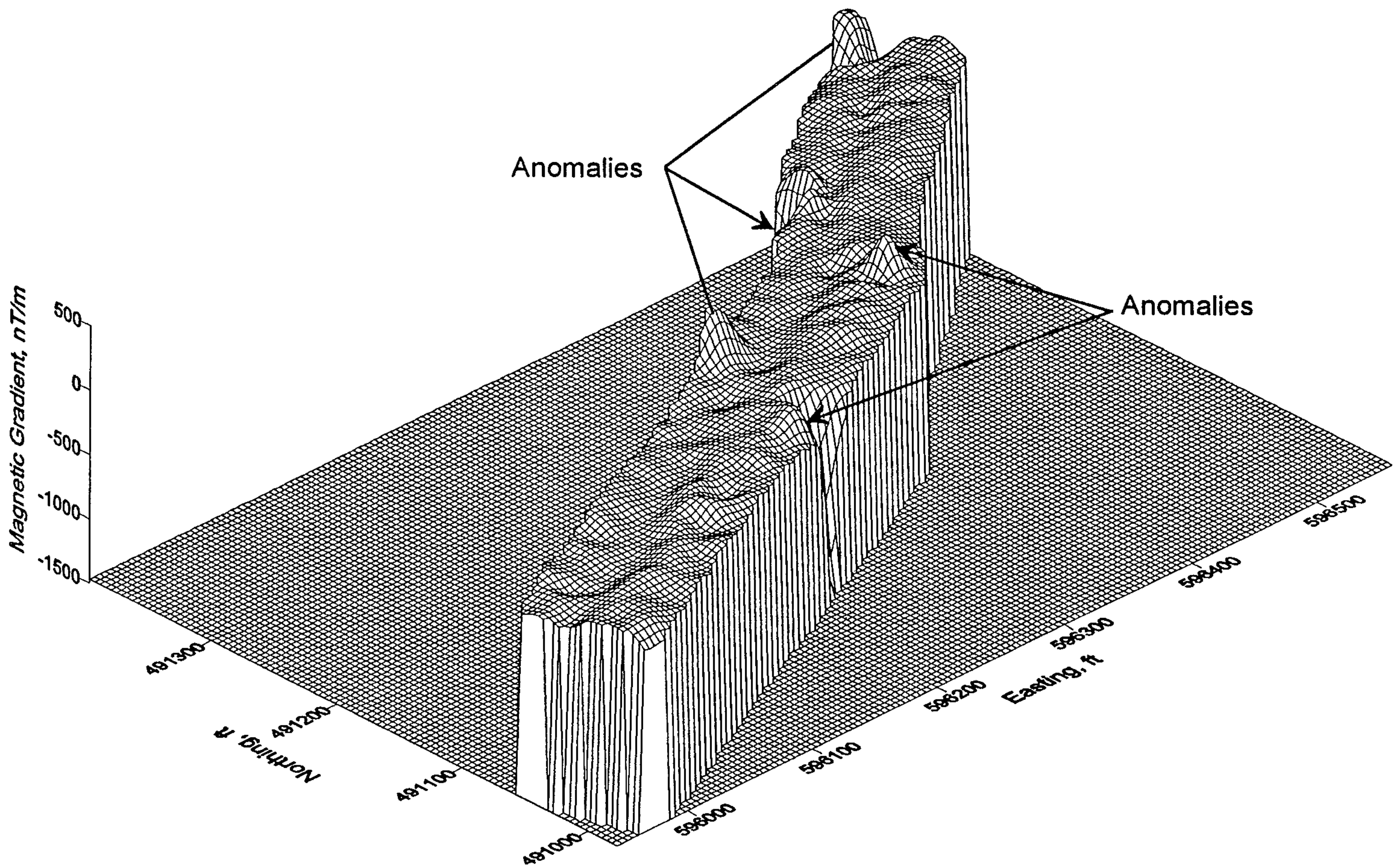
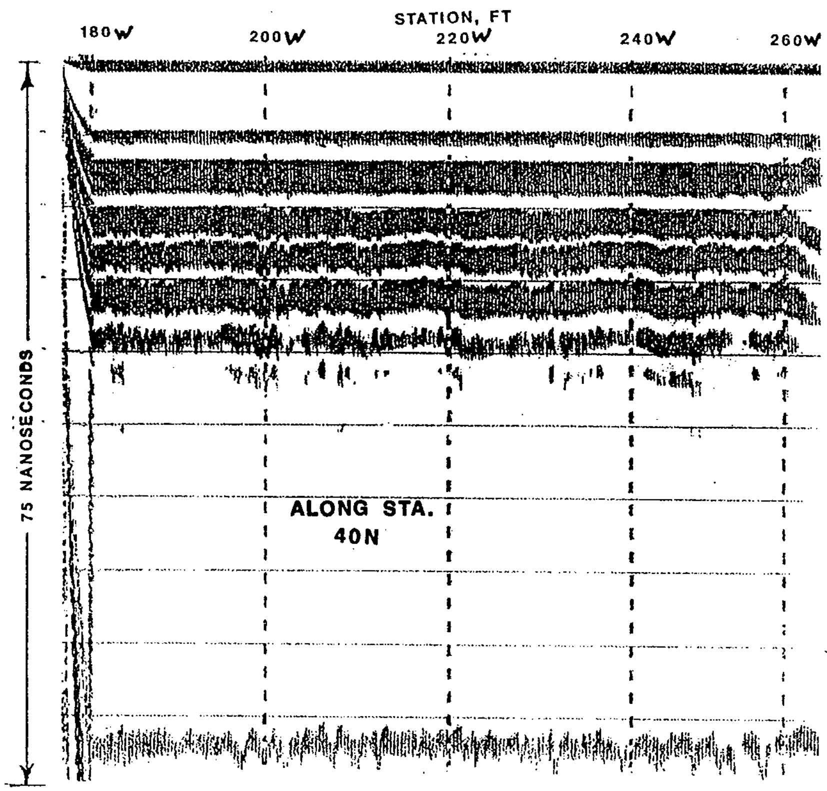
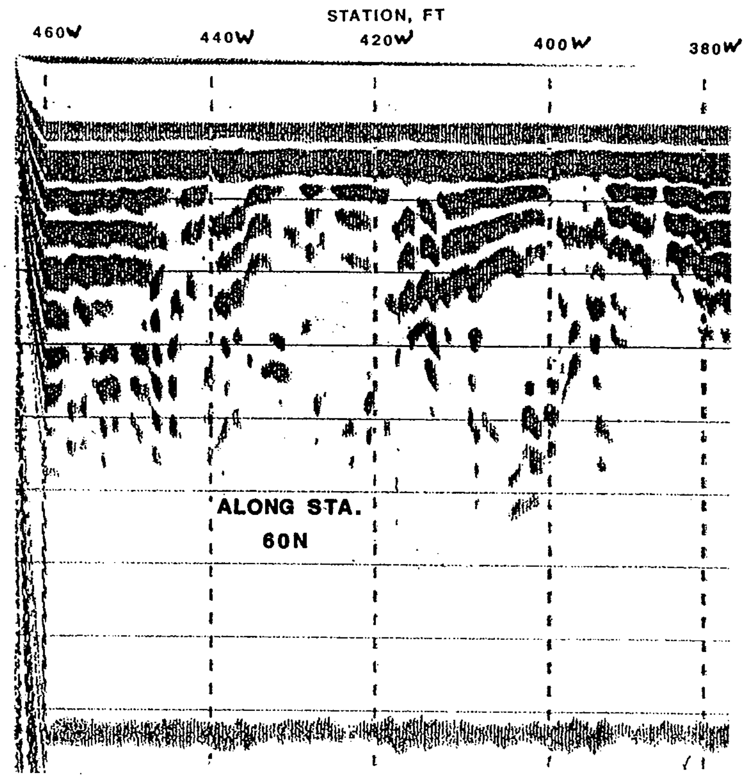


Figure 34. Magnetic gradient test results, block diagram



a. Typical GPR profile line collected at the DBG showing no anomalies (uniform lateral conditions to a depth of approx. 3 ft.)



b. GPR profile line collected at the DBG showing numerous anomalies.

Figure 35. Example of GPR profile lines

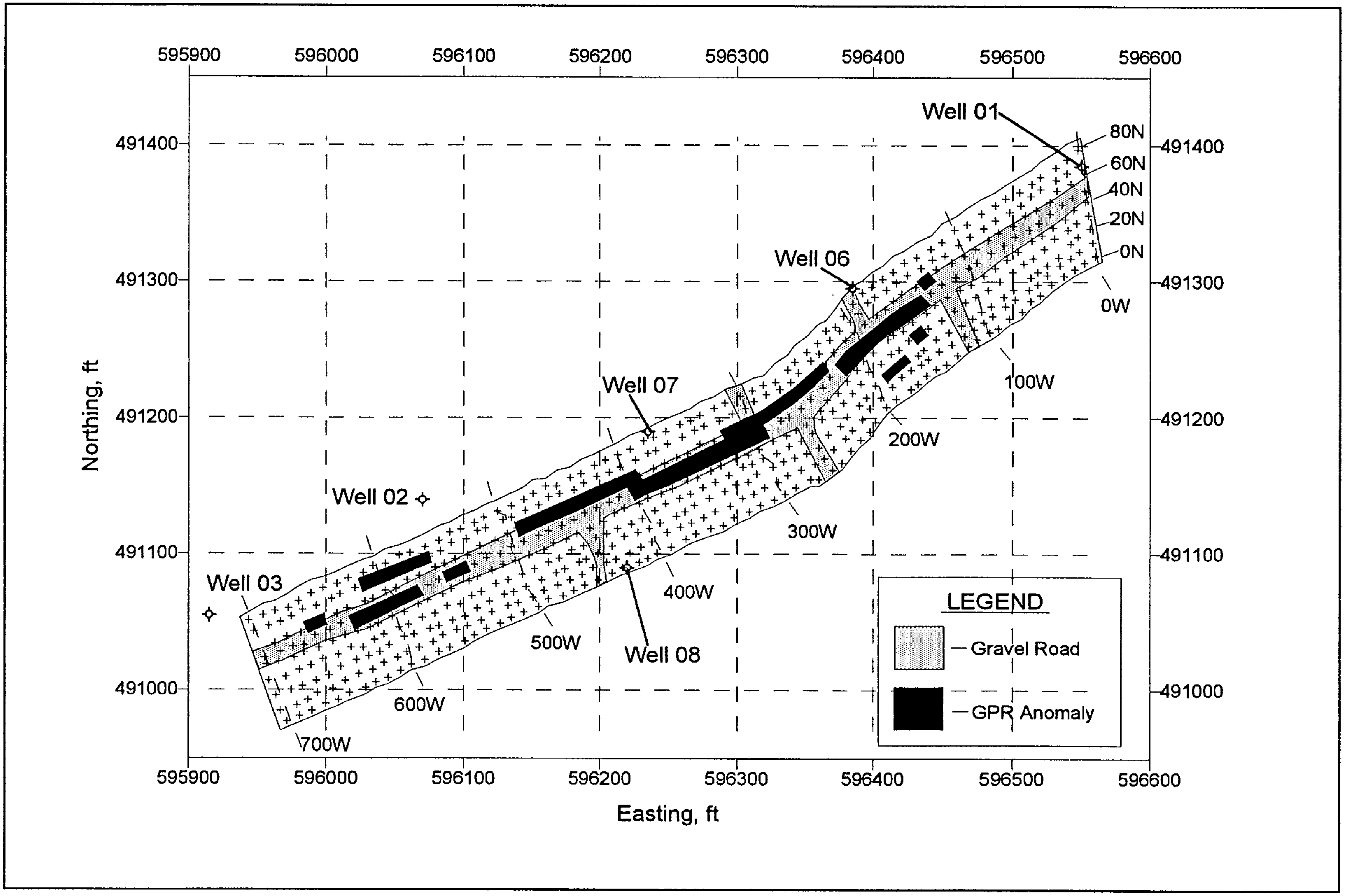


Figure 36. GPR anomaly map

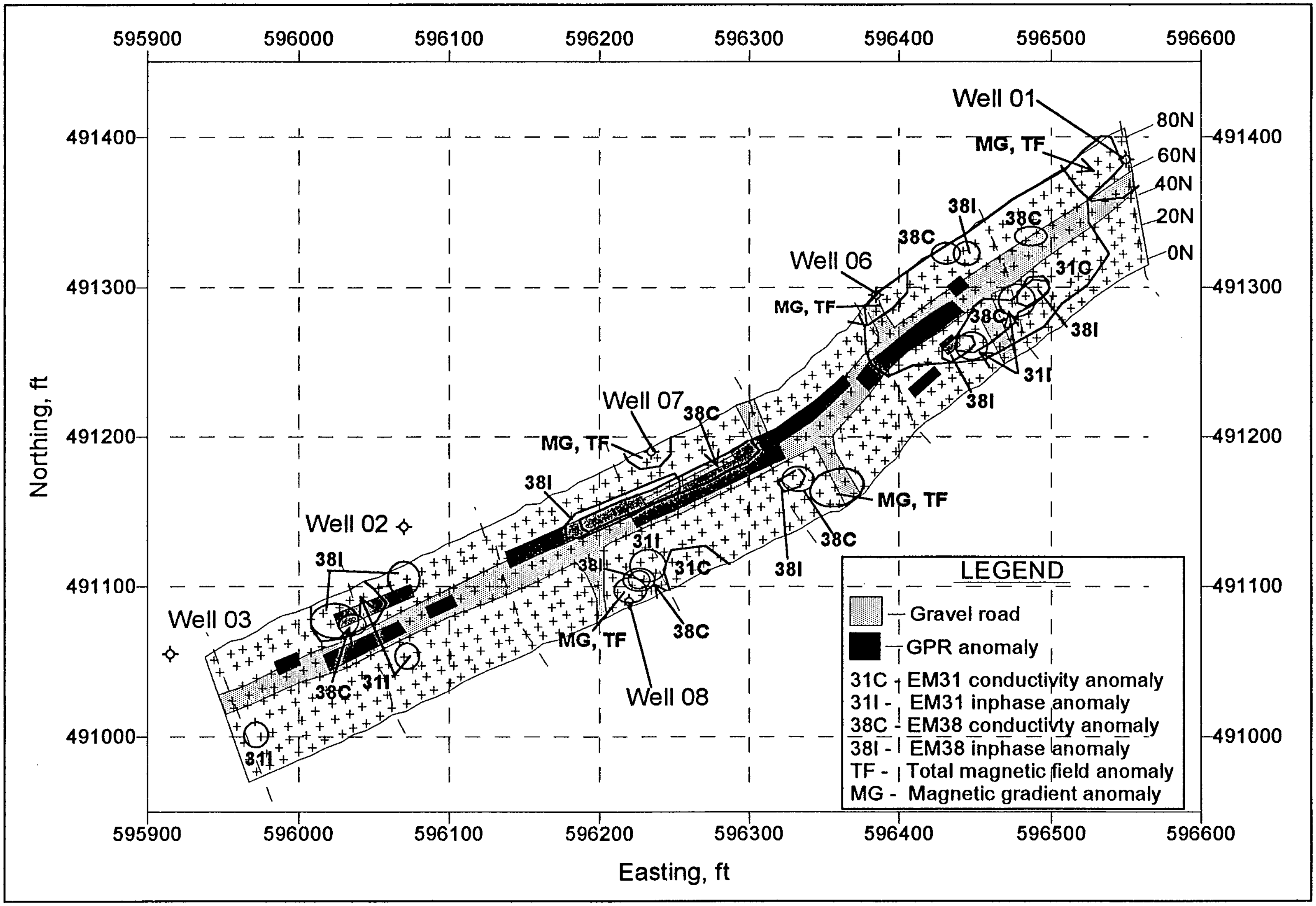


Figure 37. Integrated anomaly map

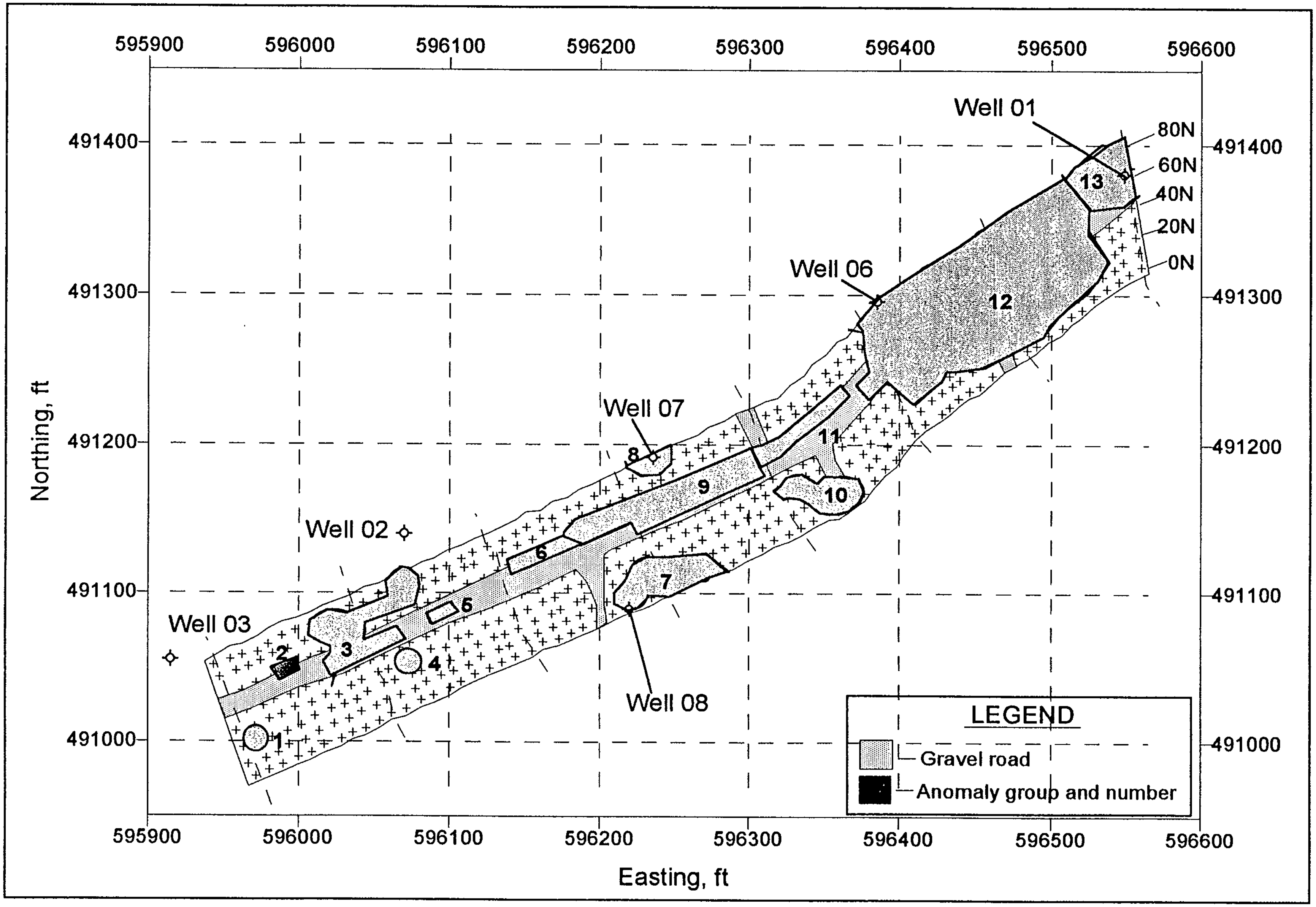


Figure 38. Geophysical test anomaly group map

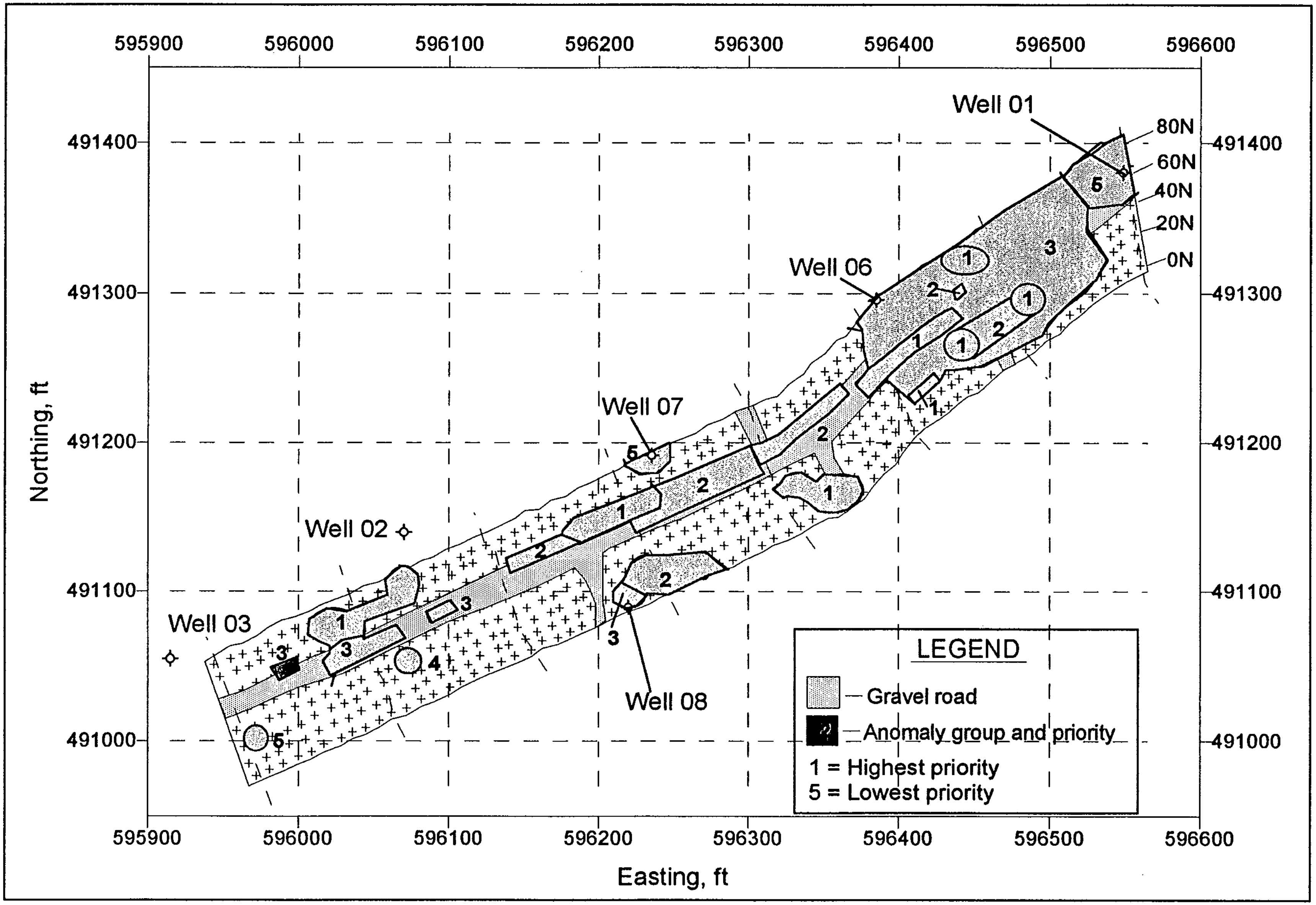


Figure 39. Geophysical test anomaly priority map

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
June 1997

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
RFI Interim Measure, Geophysical Investigation, SWMU 02/11, Dye Burial Grounds, Naval Surface Warfare Center Crane Division, Crane, Indiana

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report GL-97-6

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Southern Division Naval Facilities Engineering Command
North Charleston, SC 29419-9010

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

A geophysical investigation was conducted at the Dye Burial Grounds (DBG), Naval Surface Warfare Center, Crane Division, Crane, IN. An Initial Assessment Study (IAS) study team reported in 1983 that an estimated 50,000 lb of various dyes and dye contaminated materials were deposited in open trenches at the DBG between 1952 and 1964. Three main trenches, estimated to be 10 ft wide, 50 ft long, and 6 ft deep, reportedly included magnesium, boxes and rags contaminated with dyes, and about 60 drums of dyes. Precise location of the burial trenches was not available from records. The potentially toxic or carcinogenic dyes have reportedly overflowed the trenches during heavy rains.

The objective of the investigation was to detect and delineate anomalies indicating the locations of buried objects or disturbed zones associated with past hazardous waste burial at the DBG. The locations of these wastes are needed so they can be excavated for removal to a permanent treatment or disposal site. Electromagnetic (EM), magnetic, and ground penetrating radar (GPR) surveys were conducted at the DBG to meet this objective. Anomalies from each survey method were mapped an interpretations of their cause were tabulated. Also noted in the report is the priority in which the anomalous areas should be further investigated.

14. SUBJECT TERMS
Electromagnetic
Geophysical surveys
Geophysics
Ground penetrating radar
Magnetics

15. NUMBER OF PAGES
63

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		